Economic Aspects of Changing the Seasonality of Milk Production in New Zealand

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Abstract of a thesis submitted in partial fulfilment of the requirements for the Degree of M.Agr.Sc.

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The traditional system of milk production in NZ is seasonal, with all cows calving during late winter and early spring. Consequently, production of milk for manufacturing in New Zealand is characteristically very high in spring (about 30% of the total milk is supplied during the peak months of October and November) and virtually zero in winter. To process all the milk supplied during the peak period, adequate processing plant, transport vehicles, and storage facilities are required. These assets are under-utilised for most of the year as, on average, only 54% of the total processing capacity is used on an annual basis. In addition, the manufacturing sector is forced to concentrate on commodities, as it is not possible to manufacture high value products at the rate required during the peak milk flow. Clearly, there is considerable scope to increase processing and marketing efficiencies if more milk could be supplied over a longer portion of the year. However, any change in the pattern of milk supply is likely to increase production costs, and would therefore require appropriate price incentives.

The overall objective of this research was to explore different seasonal pricing schemes that could be implemented in New Zealand to reduce the seasonality of milk production, and to estimate the effects that such schemes might have upon farm management practices, milk supply patterns, and milk production costs, especially in the context of the South Island. To accomplish these objectives, a linear programming model of a case study South Island dairy farm was developed.

Results of the initial model runs showed that, compared to the current situation, more milk could be supplied outside the peak at no extra cost, because of the economic advantage of feeding the cows to achieve longer lactations and higher milksolids production. Therefore, no premiums would be required to encourage farmers to pursue such a practice, since it would be a more profitable alternative than the traditional system involving cows with short lactations. However, results also showed that extending the lactation would have only a marginal effect upon increasing milk throughput outside the peak period. Thus, a significant reduction in the seasonality of milk production would require adopting different calving dates. The model was then used to explore farming systems involving varying proportion of the herd calving in autumn and to calculate the costs of producing milk from these systems, under varying milksolids prices. It was concluded that the base milksolids price has an important effect on the costs of changing milk supply patterns, and hence, on the price incentives that would be required to compensate for such costs. Finally, the third phase involved simulating different payment systems that could be implemented in New Zealand to reduce the seasonality of milk supply. Results indicated that seasonal pricing schemes involving winter premiums would be the most cost effective means of encouraging farmers to change their milk supply patterns.

Keywords: Seasonality, processing and marketing efficiencies, seasonal pricing schemes, milk production costs, linear programming.

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ERRATUM FOR THESIS

" ECONOMIC ASPECTS OF CHANGING THE SEASONALITY OF MILK PRODUCTION IN NEW ZEALAND"

by Fernando Figueredo

Chapter 1

p 3 … 'shelf life'… should read … 'shelflife'

Chapter 2

p 11 … Figure 2.3 … 'Her' … should read … 'Herd'

p 17 … 'The South Island milk production curve is quite different from that of the North Island. It has a much broader spread'… should read … 'The South Island milk production curve is different from that of the North Island. It has a broader spread'…

p 18 … 'Macdonald' … should read … 'MacDonald'

Chapter 3

p 25 … 'table 3.1' … should read … 'Table 3.1'

p 25 … 'Brooks' … should read … 'Brookes'

p 27 … In Figure 3.2, it should be noted that the starting and ending LW's are different because the latter includes the fetus's weight.

p 34 … 'Legard' … should read … 'Ledgard'

Chapter 4

p 46 … 'table 4.2' … should read … 'Table 4.2'

p 46 … 'figure 4.3' … should read … 'Figure 4.3'

Chapter 5

p 54 … In the discussion about the use of Nitrogen by the model to reduce the seasonality of pasture production, it should be noted that the observed changes were small.

p 56 …In Figure 5.2, it should be noted that the diet composition of lactating cows was expressed on a DM basis.

p 61 … In Figure 5.5, 'dys' … should read … 'days'

p 63 … In the heading lines of Table 5.3 … '4 and 5' … should read …'80 and 100'

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CHAPTER 1

INTRODUCTION: PURPOSE AND NATURE OF THE STUDY

1.1 Introduction

The traditional system of milk production for manufacturing in New Zealand is seasonal, where all cows calve in a concentrated pattern in late winter and early spring. This system was developed to fit as closely as possible the high feed requirements of cows during early lactation with the spring flush of pasture growth, and the lower nutritional requirements of cows during late lactation and the dry period with the slower pasture growth in autumn and winter. Seasonal milk production is also encouraged by the current payment system in New Zealand, which involves a uniform price throughout the year. Since the dairy processing sector does not differentiate the value of the milk in terms of the handling costs at various stages of the season, dairy farmers supply milk by methods that keep production costs to a minimum. Thus, production of milk for manufacturing in New Zealand is characteristically higher in spring and virtually zero in winter, as shown in figure 1.1.

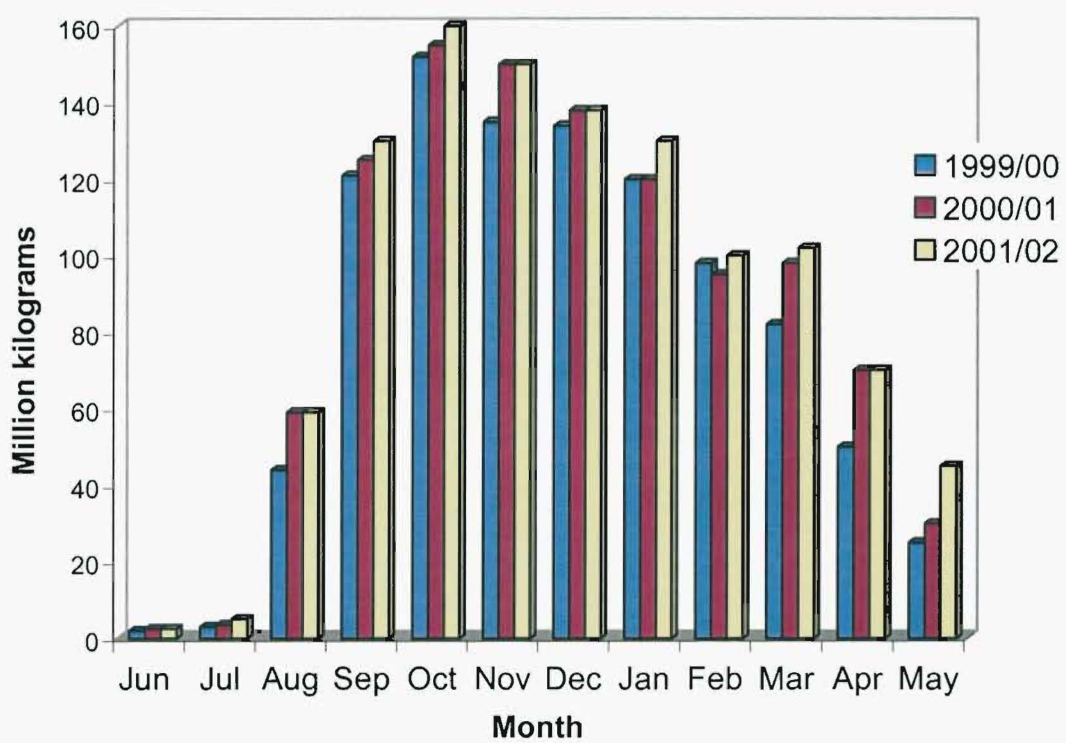

Figure 1.1: Seasonal trend in total milksolids processed in New Zealand for three seasons
Source: Dairy Statistics 2001-2002. Livestock Improvement Corporation

This highly seasonal milk supply curve is characterised by a sharp decline from the peak, at a rate of about 7-11% per month (Nelson, 2001). In contrast, the pattern of production in most other countries, where feeding of cows is not so reliant on the grazing of pasture, is more even between a flush period and an off-season (McCombs, 1986).

The seasonal nature of pastoral production, in combination with price signals that only reward total production, has led to production patterns where peak day volumes are 30 times that of the lowest day, and where the season total approaches 10,000 times the lowest day's production (Eman and Gommans, 2001). These production ratios create an industry with the following characteristics:

- Huge factories that are poorly utilised for the majority of the year: on average, only 54% of the total processing capacity is used on an annual basis. In comparison, Ireland utilises about 51%, Australia 64%, US 94%, the UK 89% and some of the other European countries are in the 80-90% range (Nelson, 2001).

- Since about 30% of total milk is supplied during the peak months of October and November (Dairy Statistics, 2000/2001; LIC), the factories must process the peak milk on the day it is received and, therefore, adequate processing plant, transport vehicles, and storage facilities are required to cope with the peak (Gray *et al.*, 1994). This creates large debt servicing and maintenance liabilities.

- Milk flows in excess of plant capacity force companies to either dump milk, or to divert milk from high value products into lower value bulk commodities. Thus, the manufacturing sector concentrates on commodities, as it is not possible to manufacture high value products at the rate required during the peak milk flow (Eman and Gommans, 2001).

- The New Zealand dairy industry is export oriented, since only 4-5% of the milk produced is consumed domestically. Thus, it is critical that, despite the marked seasonal pattern of milk production, dairy products are marketed on a 12-month supply pattern to compete offshore with the Europeans and other competitors (Nelson, 2001). This creates large stockpiles of products, with the associated risk of market change.

- Opportunities to sell high value, short shelf life products are lost during the low season from March through to August.

- Reduced capital available for marketing activities, with so much invested in massive plants and product inventories.

- Reduced milk quality during the peak milk flow, caused by colostrum and environmental bacteria contamination. Furthermore, the manufacturing efficiency of milk supplied during the peak is reduced, as the milk composition during early lactation is not optimal for processing (Auldist *et al.*, 2002). Thus, some products are more expensive, or even impossible, to make at certain times of the year, due to the seasonal variations in milk composition (Parker, 1994). For instance, seasonal changes in the quality and composition of milk powder cause problems such as sedimentation, fat separation, and noticeable changes in solubility.

Clearly, there is considerable scope to increase processing and marketing efficiencies if more milk could be supplied over a longer portion of the year. However, if it is accepted that farmers have developed low-cost and efficient pasture-based systems, any change in the pattern of milk supply is likely to increase production costs, and would therefore require appropriate price incentives.

1.2 The Research Problem

Concern has long been felt within the New Zealand dairy industry about the high costs of maintaining the capacity required to process the peak daily milk flow (Paul, 1982; McCombs, 1986; Townshend, 1994; Parker, 1994). Several studies have been carried out to examine these costs and the economics of alternative patterns of milk supply that could increase the utilisation of manufacturing plants. These studies led to the conclusion that the costs of changing farm management practices would outweigh the benefits that would accrue to the manufacturing sector (McCombs, 1986). In addition to processing efficiencies, McCombs (1986) considered the benefits that could be gained through additional sales if products could be manufactured over a longer portion of the year. The results of his study support the conclusions arrived at by previous studies.

However, conditions have changed significantly since these studies were undertaken. Farming systems and available technology, availability of supplementary feeds, prices and costs, have all changed. For instance, most dairy farms are no longer self-contained for feed (Holmes, 1998). These "new" systems might be capable of producing out of season milk at low-cost. In fact, some authors (Holmes, 1998; Garcia *et al.*, 1998) have suggested that, for some farms, a system involving a portion of the herd calving in autumn, with the remainder calving in spring, may be the lowest-cost, most efficient system. This split calving system, which is currently practiced by town supply dairy farmers, would be profitable for factory supply dairy farmers if adequate price incentives were in place. These authors contend that such a system would enable factory supply dairy farmers to produce milk throughout the year, either solely from grazed pasture, or with supplementary feeding. With this system, the stocking rate would be lowest during winter, highest in spring (when all cows are in milk), and intermediate in summer (after autumn calvers have been dried off).

Gray *et al.* (1994), using a linear programming model, studied the on-farm impact of a differential pricing scheme. The scheme used was based on a North Island dairy company where farmers supplied 30% of the total milk during the October/November peak and 70% during the off-peak period (i.e. a peak-to-shoulder ratio of 30:70). The results showed that a price differential of at least \$1.71/kg MS between peak and shoulder milk would be required to reduce peak milk production significantly. However, this study had two main limitations. Firstly, the effects of only three price differentials between peak and off-peak milk were analysed. The scheme involved discounting the price at the peak period, and reallocating this to the milk supplied at the shoulders. Thus, the study failed to explore the effects of other pricing schemes that could be implemented in New Zealand, such as those involving monthly price differentials. Secondly, only three calving dates were included in the linear programming model, namely, July, August, and September, thus failing to consider calving patterns that may have the greatest potential for smoothing the milk supply curve, such as split calving.

All of the studies referred to above were based on North Island data. Since conditions on both Islands are very different, in particular with respect to climate and soils, and the resulting pasture growth patterns, the results of such studies may not apply to the South Island. Consequently, it would be valuable to study the problem of seasonality of milk production in New Zealand with specific regard to South Island conditions.

Given that the industry in total (production, collection, processing, and marketing) is for the most part in the ultimate ownership of the farmers, the principles for deciding on the desirability of alternative pricing systems and calving dates are straightforward; that is, any pricing mechanism, and resulting supply pattern, will be desirable if the increased efficiencies and returns outweigh the increased costs. In other words, if there is a net benefit overall from an alternative supply pattern, it will ultimately represent an increased return either directly or indirectly to the farmer.

Clearly, it would be possible to improve efficiency by increasing the throughput. However, would it be optimal for the system as a whole to have a high degree of efficiency at the processing level relative to farm efficiencies? Would a compromise solution be more profitable? How can the efficiency of the whole system be increased? Clearly, there is a trade-off between processing efficiency and farming efficiency, since the efficiency at one level is achieved at the expense of the efficiency at the other.

This question can be answered in three steps. Firstly, the farmer's costs and returns that are associated with alternative milk supply patterns must be determined in order to estimate the increased production costs resulting from such responses. The processing sector must then determine whether the savings in collection and processing costs, as well as the increased returns from a better product mix, would outweigh the increased production costs at the farm level. Finally, the milk supply pattern that would offer the greatest profit to the dairy industry as a whole must be selected.

This study focuses on the first aspect of the problem; that is, on the farm sector. By paying the real cost of milk production as it changes through the season there could be significant changes to production patterns, assuming farmers are responsive to price incentives. The size of the swing from spring calving to out of season calving will depend on the pricing levels and the extra costs incurred. The size of the changed milk price structure should, theoretically, determine the changes to the farming patterns and resulting milk supply patterns.

1.3. Objectives of the Study

The overall objective of this research is to explore economic aspects of changing the seasonality of milk production in New Zealand through changing farm management practices. In particular, this study explores different pricing schemes that could be implemented in New

Zealand to reduce the seasonality of milk production, and considers the effects of the schemes upon farm management practices, milk supply patterns, and milk production costs in the South Island, assuming the farmers are economically rational.

Specifically, this research aims to:

(i) estimate the increased production costs of moving away from seasonal production,

(ii) predict a case study dairy farmer's responses to seasonal price incentives, and estimate the increased production costs associated with such responses, and

(iii) determine the pricing scheme (levels and timing of price incentives) that may be required to encourage the case study dairy farmer to change his milk supply pattern.

1.4 Method of Study

To estimate the production costs associated with out of season milk production, and to predict the likely changes that farmers would make to their farming systems in response to price signals, the farm as a whole must be considered. That is, the impact of the changed profitability at the margins upon the whole farm business should be analysed. Since complex interactions occur between components within the system, simple marginal analysis is not appropriate when making substantial changes to a farming system.

Complex biological systems, which are characterised by complex non-linear relationships, are best represented by systems simulation models. Such models are usually constructed to accurately represent the particular features of the system being modelled by means of equations. A wide range of computer routines may be employed. However, these models are experimental in nature, in contrast to prescriptive (optimising), which is required for the proposed research. Several algorithms have been developed to optimise such models, but they are extremely complicated, if not impractical.

This study requires an analytical technique that is simple, practical, and prescriptive in nature. Linear programming (LP) meets these requirements. The standard LP technique has several advantages. The algorithm or solving routine is optimising, and the basic structure of the model is a linear version of the classic economic problem; that is, choice among alternative processes that require varying amounts of limited resources. However, this technique also has limitations. These include the deterministic nature of the model, the essential postulate of linear relationships between variables, and the implicit assumption that the linear objective function of the model represents management objectives accurately.

Nevertheless, these limitations do not preclude the use of linear programming for this study, because of the following reasons:

(i) the nature of the problem under analysis and the objectives of this research require the use of an optimising model, which allows comparisons to be made with all factors in the model optimised, while representing the bio-economic relationships with reasonable accuracy, and

(ii) a linear profit objective function is acceptable since a normative approach was adopted. Hence, the linear programming model was used to determine the increased production costs of out of season production systems, as well as to determine the optimal calving patterns given different milk pricing schemes, thus estimating farmers' 'theoretical' responses to such schemes.

Finally, it was necessary to select a suitable case study farm, or construct a representative or hypothetical farm for the study. It was decided that the most suitable method was to construct a model of a case study farm for which reliable data were plentiful and which was not atypical of South Island dairy farms in management or resources.

1.5 The Case Study Farm

The dairy farm selected for the study is similar to the average Canterbury dairy farm (Dairy Monitoring Report (MAF, 2002)). It is located 10 kilometres north of the Rakaia township, and 40 kilometres from Christchurch. The farm is owner-operated, and supplies milk to Fonterra's Clandeboye factory. It has average annual rainfall of 625 millimetres. It has 170 hectares under irrigation used for the milking herd. Of these, 94 hectares are under border dyke irrigation, and 76 hectares are under spray irrigation. The dry cows are wintered on a 89-ha dry land block located nearby. The calves are grazed on a 19-ha block under spray irrigation.

All the land on this property is flat. The soil of the farm is Waimakiriri stony silt loam, with moderate fertility levels. This soil type is subject to leaching under irrigation or heavy rainfall.

Pasture production is around 12,500 kg DM/ha/yr, which compares well with the average situation in Canterbury (Thom, 2000). This growth includes around 1,140 kg DM/ha/yr of nitrogen-boosted growth (114 kg N/ha/yr is applied on an average year). The stocking rate is lower than the average stocking rate observed in Canterbury (2.6 vs 3 cow/ha, Dairy Monitoring Report, 2002). On the other hand, milksolids production per cow is higher than in the average Canterbury farm (430 vs. 350 kg MS/cow, Dairy Monitoring Report, 2002).

1.6 Thesis Outline

Chapter 2 contains a description of the main features of the New Zealand dairy industry, with particular reference to the South Island. Chapter 3 contains a description of the structure of the linear programming model developed for this study. Chapter 4 contains a description of the procedures used in evaluating the model, and in Chapter 5 there is a discussion of the results of the research. Finally, Chapter 6 has a summary of the conclusions, implications and limitations of this study and gives suggestions for further research.

CHAPTER 2

THE NEW ZEALAND DAIRY INDUSTRY

2.1 General Features

There are two factors of paramount importance which underlie the economic position of the New Zealand dairy industry (Mitchell, 2001). First, and best known, is the pasture-based milk production system. This seasonal-calving, high stocking rate pasture-based system is possible in New Zealand due to a temperate climate that allows the year-round, albeit seasonal, supply of high quality pasture. Efficient pasture utilisation through the integrated management of pasture and livestock is the economic cornerstone of the dairy industry and the source of the industry's comparative advantage internationally. The second defining feature of the New Zealand dairy industry is its export orientation. Thus, New Zealand is unique in the world in that the bulk of the milk produced (around 95%) is destined for manufacture for export (Statistics New Zealand, 2000), whereas the bulk of the milk in most other countries is destined for local consumption, largely as liquid milk or fresh product (Boland, 2002).

The New Zealand dairy industry is a vertically integrated co-operative system, owned and controlled by the supplying shareholders. In the past the New Zealand Dairy Board has been responsible for the marketing and export of all dairy products from New Zealand. The structure of the industry has changed recently, with a merger between the two largest dairy companies and the New Zealand Dairy Board to create Fonterra Co-operative Group Ltd.

The dairy industry has long held its place as New Zealand's biggest merchandise exporter and foreign exchange earner. In recent years dairy export returns have been steadily rising and in the year 2001 increased by a spectacular 51% to $7.6 billion despite trade barriers said to be costing $2 billion in lost income (Edmond, 2002).

Milk production grew during the 1990's at 7.5% annually, as shown in Figure 2.1.

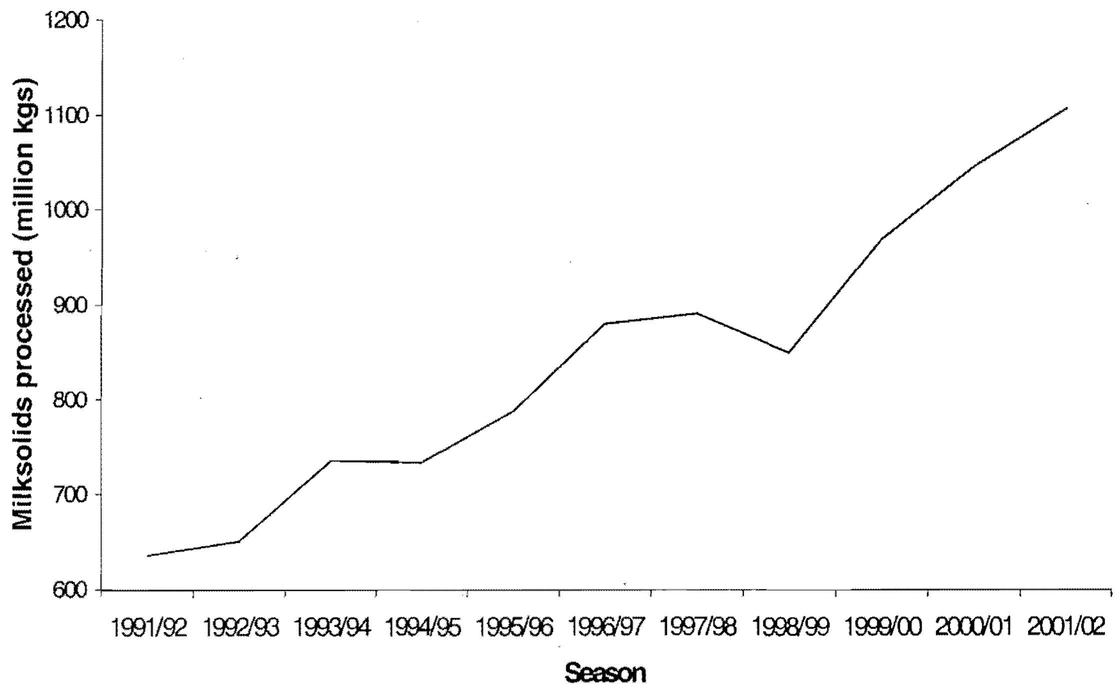

Figure 2.1: Milk supplied to factories between 1991/92 and 2001/02
Source: Dairy Statistics 2001-2002. Livestock Improvement Corporation

The majority (83%) of dairy herds are located in the North Island, with the South Auckland region the most heavily populated with 32% of the dairy herds, followed by Taranaki, with 17% of the herds. South Island dairy farms account for 17% of the national total (Livestock Improvement Corporation, 2002). Figure 2.2 shows the distribution of dairy herds within the regions of each island in 2001/2002.

The average herd size is showing an increasing trend, whereas the total number of farms is trending downwards, as shown in Figure 2.3 (Livestock Improvement Corporation, 2002).

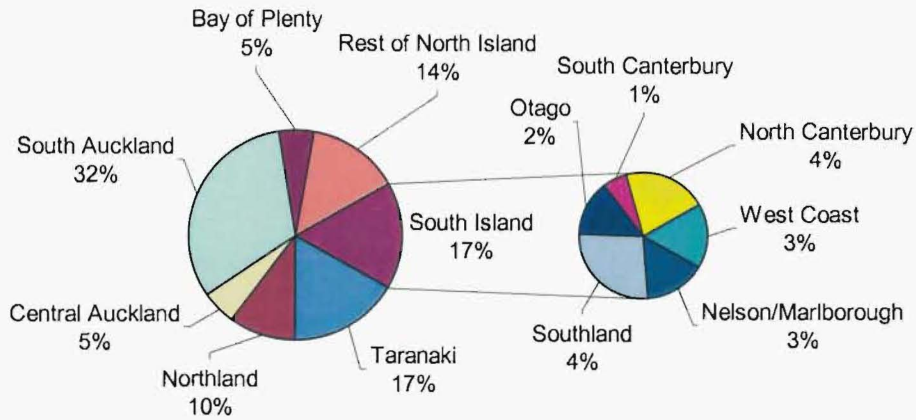

Figure 2.2: Regional distribution of New Zealand dairy herds in 2001/02
Source: Dairy Statistics 2001-2002. Livestock Improvement Corporation

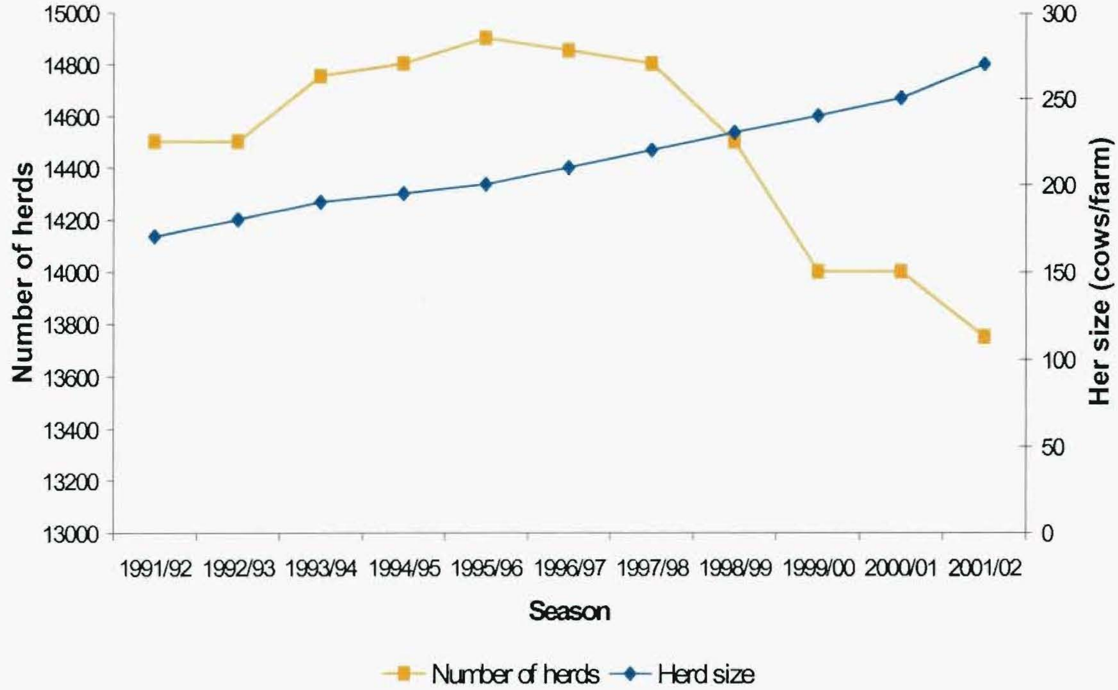

Figure 2.3: Trend in the number of herds and average herd size between 1991/92 and 2001/02
Source: Dairy Statistics 2001-2002. Livestock Improvement Corporation

Milksolids production per cow and per hectare increased steadily between 1992/93 and 2001/02, as shown in Figure 2.4. The improvement in milksolids production per hectare was driven by increasing both per cow production and stocking rate. This movement towards increased intensification was probably supported by an increased use of bought-in supplements, mainly nitrogen fertilizer, grazing off, and silages.

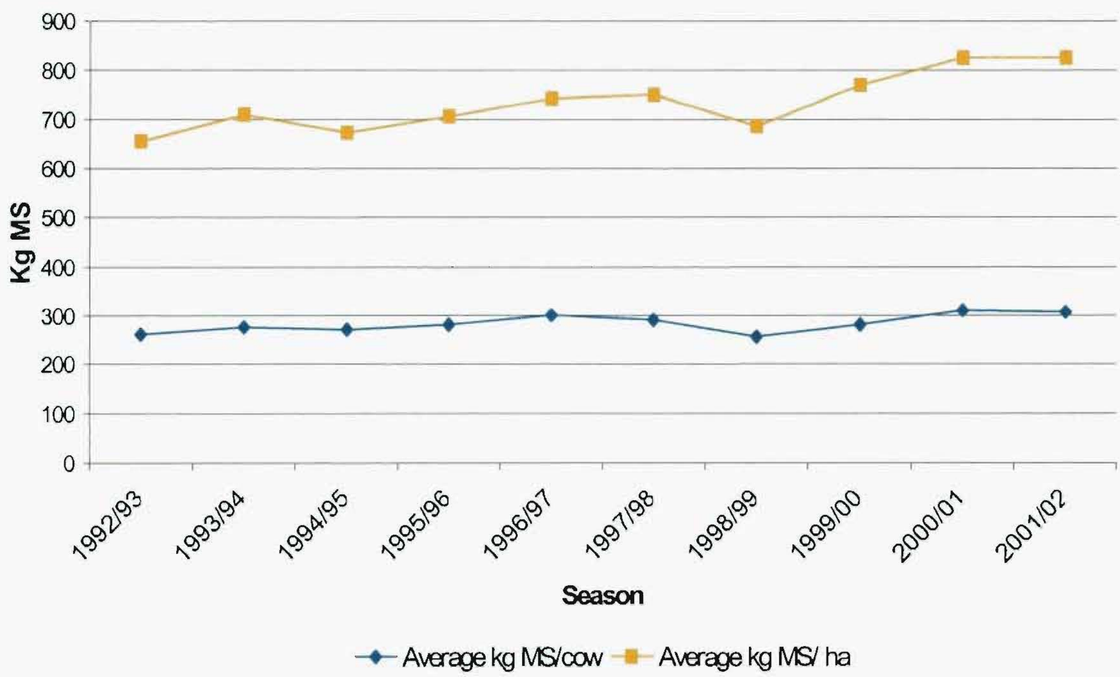

Figure 2.4: Milksolids production per cow and per hectare: 1992/93 to 2001/2002
Source: Dairy Statistics 2001-2002. Livestock Improvement Corporation

Up until the end of the 2000/01 season, dairy farmers received payment from the New Zealand Dairy Board through a system of advance and final payouts via dairy companies. Seasonal supply dairy companies passed on the Dairy Board advance payout to its suppliers in addition to a margin based on dairy company efficiency, product mix and investment policies, together known as the total payout. After the industry restructuring process was completed in 2001, this payment system became redundant. Payments to seasonal supply farmers are still based upon the "A + B – C" system, which incorporates payment for milkfat (A) and protein (B) with penalties for milk volume (C) (Livestock Improvement Corporation 2002). This system involves a uniform price throughout the year. Figure 2.5 presents the average payout received by seasonal supply dairy farmers between 1990/91 and 2001/02. The average payout is given in both nominal and inflation adjusted dollars using the Consumer's Price Index (Livestock Improvement Corporation, 2002). The high milksolids prices achieved during the 2000/01 and 2001/2002 seasons were due mainly to high international prices and a weak New Zealand dollar.

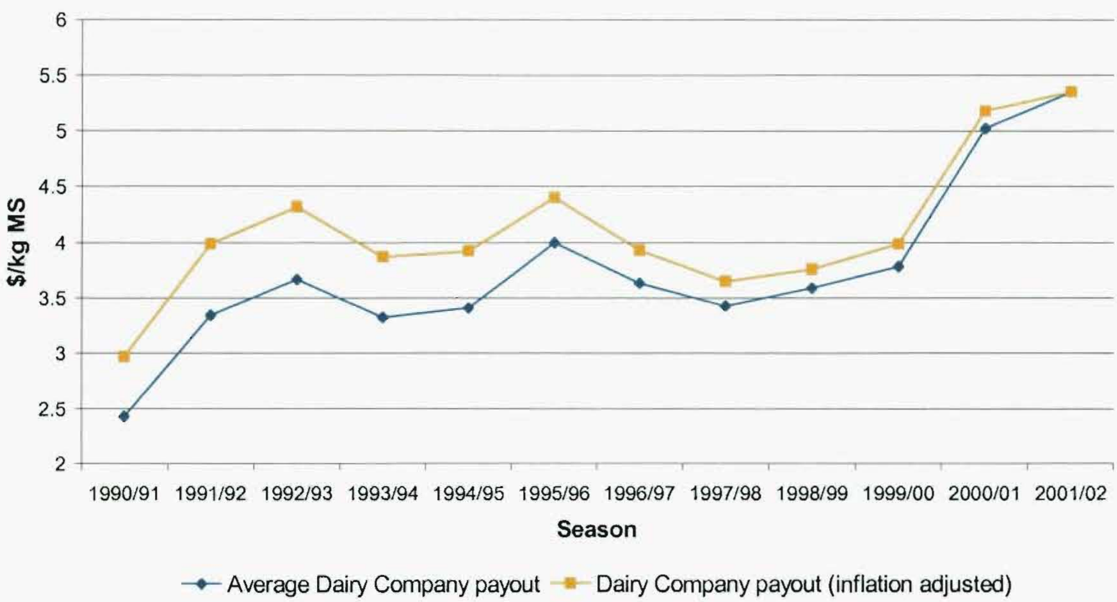

Figure 2.5: Milksolids payout to dairy farmers between 1990/91 and 2001/02
Source: Dairy Statistics 2001-2002. Livestock Improvement Corporation

2.2 Seasonality of Milk Production in New Zealand

Seasonality of production can be defined as a regular or recurring pattern of peaks and troughs within each successive year in the supply of a product. Inevitably, seasonality is most common in the pattern of output from the agricultural sector, as most farm enterprises are closely related to the natural seasonal pattern of crop growth (Keane and Killen, 1980). This is particularly true for pasture-based livestock production systems, as practiced in New Zealand.

In most regions of New Zealand, pasture growth is much faster in spring than in winter, and the seasonal production system tries to synchronise the herd's feed requirements with the rate of pasture growth (Holmes *et al.*, 2002). Consequently, all cows must become pregnant during the short period from October to December, calve in July to September (late winter or early spring) and produce milk during spring, summer, and autumn. Finally, they are dried-off before winter, so that their dry period occurs during the period of the year with the slowest pasture growth.

This seasonal milk production system has several advantages. Firstly, it ensures that grazed pasture, which is the cheapest feed, provides most of the herd's feed, and that relatively small quantities of silage or hay are conserved. Secondly, it allows large savings to be made on buildings, machinery, and labour, as the cows remain out doors throughout the year and harvest their feed directly. Thirdly, the seasonal system simplifies work and management on the farm. Thus, the period of calving and calf rearing, as well as mating, lasts only ten to twelve weeks each year. In addition, heat must be detected for only three to six weeks each year, and becomes easier, as large numbers of cows are on heat simultaneously, resulting in vigorous, visible activity (Holmes, 2001).

Although the seasonal milk production system allows minimising milk production costs, it also presents disadvantages. Hence, the need for synchrony between feed demand and pasture growth means that lactation length is generally short in New Zealand (national average of 227 days in milk) (Livestock Improvement Corporation, 2002). Consequently, it is estimated that only 25-30% of the cows lifetime feed intake is directed towards milk production, and in this respect, the utilisation of pasture for milk production is relatively inefficient (Lean *et al.*, 1996). Furthermore, the heavy reliance on grazed pasture means that the systems are very dependent on good weather to promote fast pasture growth (Holmes *et al.* 2002). Consequently, milk yields can vary widely between seasons. This variability can be reduced by management strategies such as feeding supplements in periods of pasture deficit, or by irrigating the pastures during dry spells, as is generally practiced in many areas in Canterbury.

2.3 Dairy Production in the South Island

A key feature of South Island dairy farming is the extreme variability in terms of climate, soils, farm and herd size, and production characteristics (Hughes, 1999). For instance, in some areas of the West Coast, rainfall is plentiful, whereas on the eastern side of the Southern Alps, particularly in Canterbury, irrigation is generally required for up to 6 months each season. Dairy regions in the South Island include the coldest and warmest regions as well as the driest and sunniest in New Zealand (Hughes, 1999).

Dairy farms in the South Island are, on average, larger than those in the North Island in terms of both physical size and cow numbers, as shown in table 2.1

Table 2.1: Average farm size, herd size, and stocking rate in 2001/02

	Average farm size (effective hectares)	Average herd size (number of cows)	Average stocking rate (cows/ha)
North Island	93	246	2.65
South Island	151	394	2.61
New Zealand	*103*	*271*	*2.63*

Source: Dairy Statistics 2001-2002. Livestock Improvement Corporation

The average stocking rate is marginally lower in the South Island than in the North Island. Within the South Island, South Canterbury has the highest stocking rate (2.85 cows/ha), whereas the West Coast has the lowest stocking rate (2.13 cows/ha).

Total dairy cow numbers in the South Island have increased from 206,000 in 1991/92 to 888,000 in 2001/02. This represents a compound annual growth rate of about 16% compared with a North Island increase of only 3% over the same period (Livestock Improvement Corporation, 1993 and 2003). Over the same period, stocking rates have increased by about 18% in the South Island, compared with static rates in the North Island.

In 2001/2002 average milksolids production per hectare and per cow was higher in the South Island than the North Island. Average milksolids production per hectare has been higher in the South Island over the last four seasons (see Figure 2.6). Before the 1998/99 season, milk production per hectare had been consistently lower in the South Island, due to, in part, lower stocking rates.

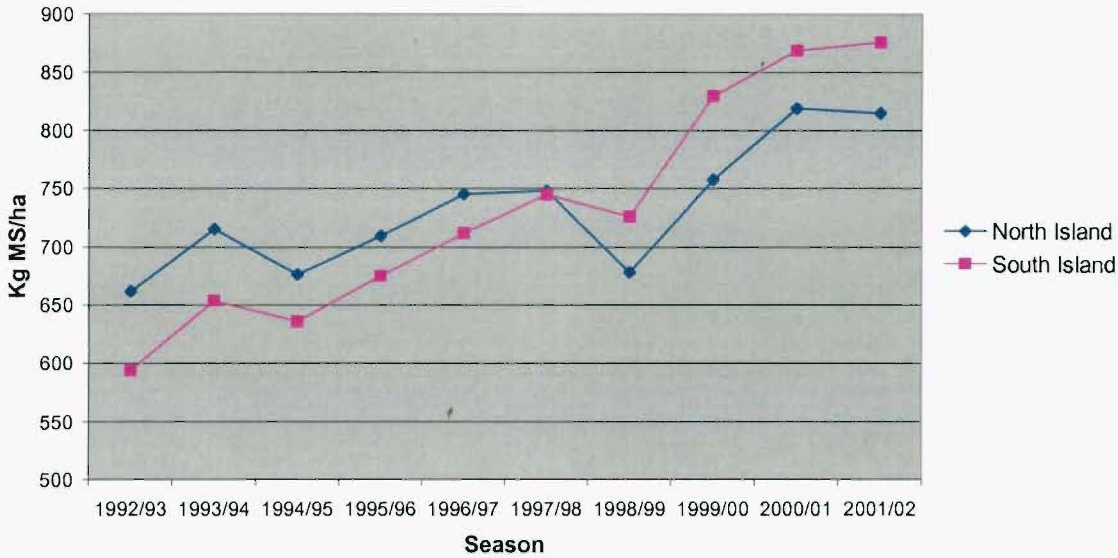

Figure 2.6: Average milksolids production per hectare in both islands between 1992/93 and 2001/02. Source: Dairy Statistics 1992/93, 1993/94, 1994/95, 1995/96, 1996/97, 1997/98, 1998/99, 1999/00, 2000/01, 2001/02. Livestock Improvement Corporation

Milksolids production per cow has been, in general, higher in the South Island than in the North Island, as shown in Figure 2.7.

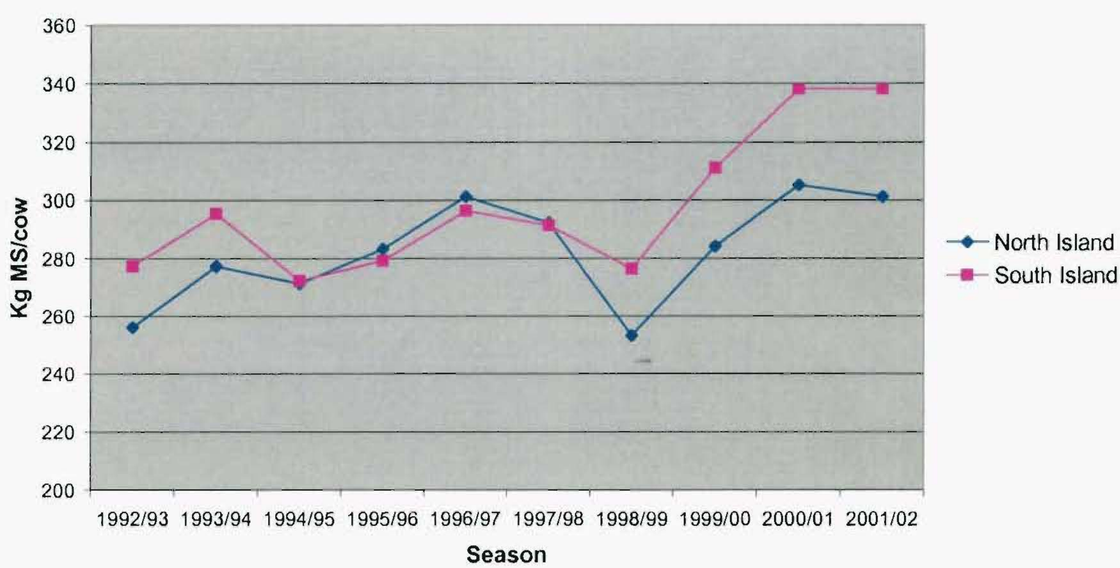

Figure 2.7: Average milksolids production per cow in both islands between 1992/93 and 2001/02. Source: Dairy Statistics 1992/93, 1993/94, 1994/95, 1995/96, 1996/97, 1997/98, 1998/99, 1999/00, 2000/01, 2001/02. Livestock Improvement Corporation

At present the South Island accounts for about 25 % of total milksolids production in New Zealand (Chalmers, 2002) and projections suggest that this figure will reach 30% by 2010 (Gaul, 2000). This growth has led to difficulties for the milk processing factories in absorbing the increased peak milk flow.

The South Island milk production curve is quite different from that of the North Island. It has a much broader spread with a bigger percentage of milk supplied outside of the peak, as shown in figure 2.8. According to Thompson (1999), the differences in the monthly distribution of milk supplied to North and South Island dairy factories are due mainly to climatic influences on the seasonal distribution of pasture production.

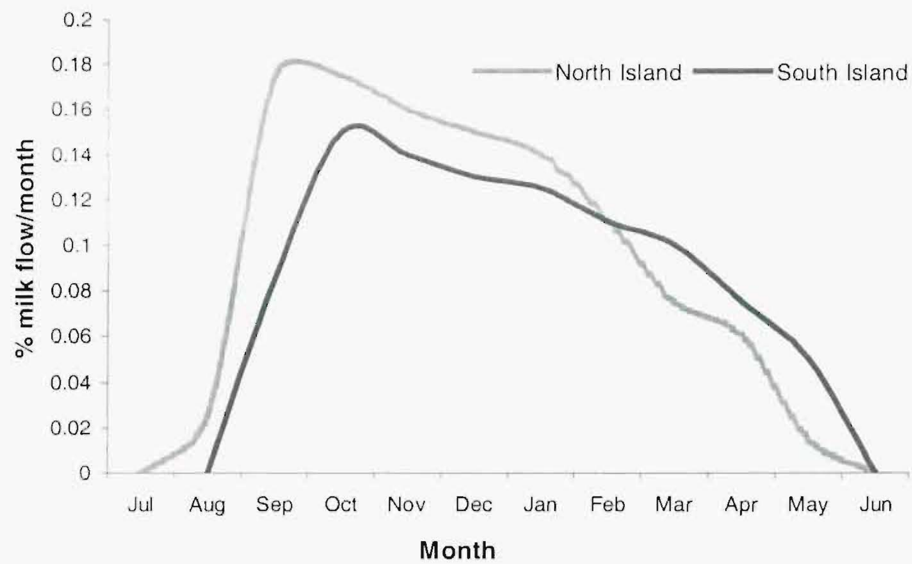

Figure 2.8: Monthly distribution of milk supplied to North and South Island dairy companies.

Source: Thompson (1999)

A comparison of pasture production in different dairying regions supports this claim, and indicates that the contribution of spring pasture production to the total pasture dry matter production declines from North to South, thus influencing the milk supply patterns, as shown in table 2.2.

Table 2.2: Comparison of pasture production and average milk flows (1997/98 and 1998/99 seasons) to North and South Island factories

	% of production in spring (September, October, and November)		Date when 70% of total production is reached
Processing plant/Region	**Pasture**	**Milk**	
NZCDC – Waikato	41	45	17 December
Kiwi – Taranaki	47	42	1 January
Tasman – Golden Bay	38	39	11 January
NZCDC – Clandeboye	35	38	13 January
Westland – West Coast	-	34	16 January
NZCDC - Edendale	-	34	20 January

Source: Thomson (1999)

In the South Island, there is a need for extra supplementation compared with the North Island, as pasture growth is restricted to a shorter period (Macdonald, 1999). Thus, pasture growth during winter is much lower in the South Island than the North Island, which explains the later calving dates in the South Island, as shown in Figure 2.9.

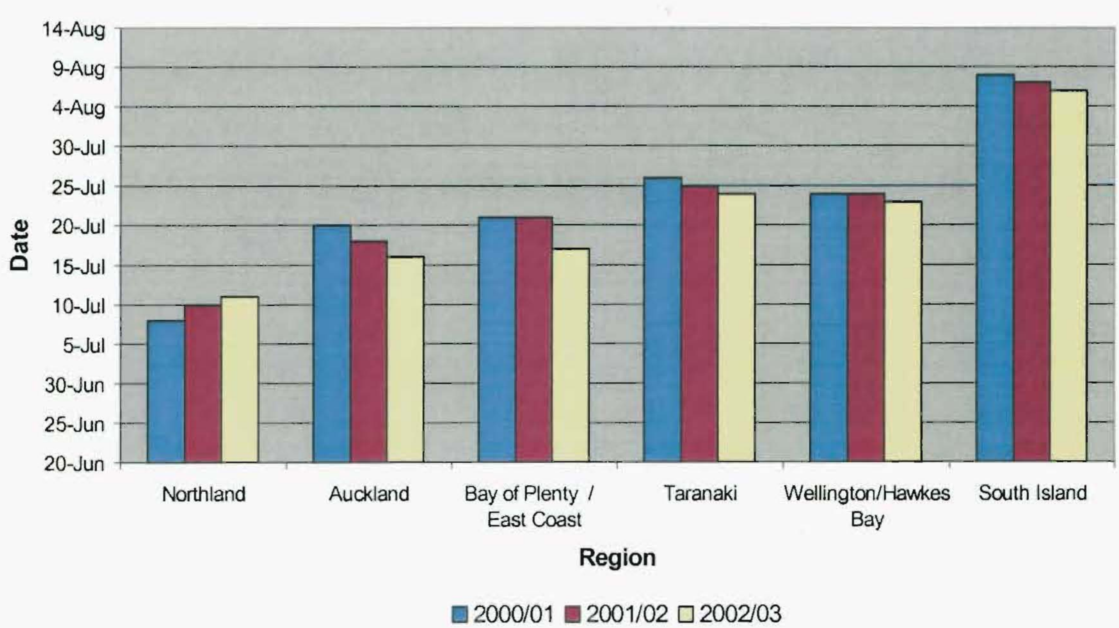

Figure 2.9: Planned start of calving dates by region

Source: Dairy Statistics 2001-2002. Livestock Improvement Corporation

Despite later calving dates in the South Island, lactation length does not differ between the islands. Herds are probably dried off later in the South Island because of better summer and autumn feed supplies, marginally lower stocking rates, and the ready availability of grazing off and supplementary feed.

Forage crops are playing an increasingly important role in the dairy industry as it expands and intensifies in the South Island (Hogg *et al.*, 2002). The environment in the South Island is ideal for the production of cereal forages and grains, creating the potential for a steady supply of such feeds for dairy farmers. In particular, whole crop cereal silage is a promising area of potential integration of the cropping and dairy industry (Platfoot and Stevens, 2002). The use of whole crop cereal silage to feed dairy cows provides several advantages. Firstly, cereal crops such as wheat, barley, or triticale offer high quality forage in regions where maize silage is not suitable due to climatic conditions. Secondly, large quantities of cereal forage can be grown either on farm or on contract. New cereal varieties are being developed to provide improved yield potential and better silage quality (De Ruiter *et al.*, 2002). Thirdly, dairy farmers can gain the benefits of cereal growing expertise without having to invest in the technology required to grow such crops.

Despite longer winters with lower pasture growth rates in the South Island relative to the North Island, some areas in the South Island are ideally suited to year-round milk production, given free-draining soils, irrigation, and access to cheap, bought in supplements (Hughes, pers. comm.).

2.4 Summary

Milk production costs in New Zealand are amongst the lowest in the world as production is based largely on temperate pastures which provide a low-cost feed supply. The reliance on grazed pasture as the main source of feed causes a highly seasonal milk production pattern, with most of the milk supplied in the spring and summer, and little in winter. Another distinctive feature of the New Zealand dairy industry is its export orientation.

The New Zealand dairy industry has shown a dynamic growth trend, increasing output and international market participation during the nineties, and has recently successfully completed a restructuring process.

On average, the South Island has the largest and most productive herds in the country, but it has shorter periods of pasture growth than in the North Island. These are partially compensated by the availability of high quality, relatively cheap supplements, such as barley grain and whole crop cereal silages. Some areas in the South Island are ideal for out of season milk production.

Milk production in the South Island has shown significant growth over the last few years. This trend is expected to continue, and projections suggest that the South Island will produce about 30% of the total milksolids production in New Zealand by the year 2010. This growth is placing a heavy pressure on the milk processing factories.

CHAPTER 3

MODEL DEVELOPMENT

3.1 Introduction

In Chapter 2, the particular characteristics of South Island milk production were discussed. Factors such as the extra need for supplementation, shorter periods of pasture growth, and the suitability of certain areas for year-round milk production, were highlighted. The linear programming model used in this research incorporates these characteristics.

The model was developed in three stages, namely: information gathering, model construction, and model evaluation. In this chapter, the first two stages are described. The structure of the model, the relationships assumed, and the coefficients used are discussed. Model evaluation is discussed in the next chapter.

3.2 Information Gathering

This process involved a multi-disciplinary approach including a review of the literature and consultation with researchers, plant and animal scientists, consultants, and dairy farmers. It was a comprehensive exercise, aimed at getting all the data needed to construct the model, namely: the objective function coefficients, the input-output coefficients, the right hand side values, and the constraints required to ensure model adequacy.

Some data were particularly difficult to get, even impossible in some cases, due to gaps in the scientific knowledge of certain aspects of farming systems. For example, no published work was found as to feed losses associated with *in situ* conservation of pasture at various times of the year. Thus, subjective estimations had to be made in many cases. The validity of such estimations was then assessed by experts in the area of knowledge concerned.

3.3 Model Construction

Model construction involved designing the model in matrix form, incorporating decision variables, constraints and inter-relationships between variables that were judged necessary for a realistic representation of the farm system. Once the basic structure of the model was complete, the matrix coefficients were calculated. This process was carried out in small steps. Thus, several versions of the model were constructed, each subsequent version incorporating higher levels of complexity and refinement. The final version of the model comprises 482 activities and 270 constraints. The full model can be found in Appendix E. A detailed description of the model structure follows.

3.4. Model Description

The model is a linear programming model of a case study South Island dairy farm. It represents a single year production cycle divided into 26 fortnightly sub-periods. Since the system is assumed in equilibrium, feed inventories at the start and end of the year are equal, through feed-transfer activities. The model selects stocking rates, feed inputs, calving dates, lactation lengths, milk production levels and resulting patterns of milk supply that maximize the objective function.

The model comprises two sub-models:

(A) milk production and selling sub-model, and

(B) cow nutrition sub-model.

These sub-models are linked by the cow activities, which are the pivotal components of the model. An overview of the model structure is shown in Figure 3.1.

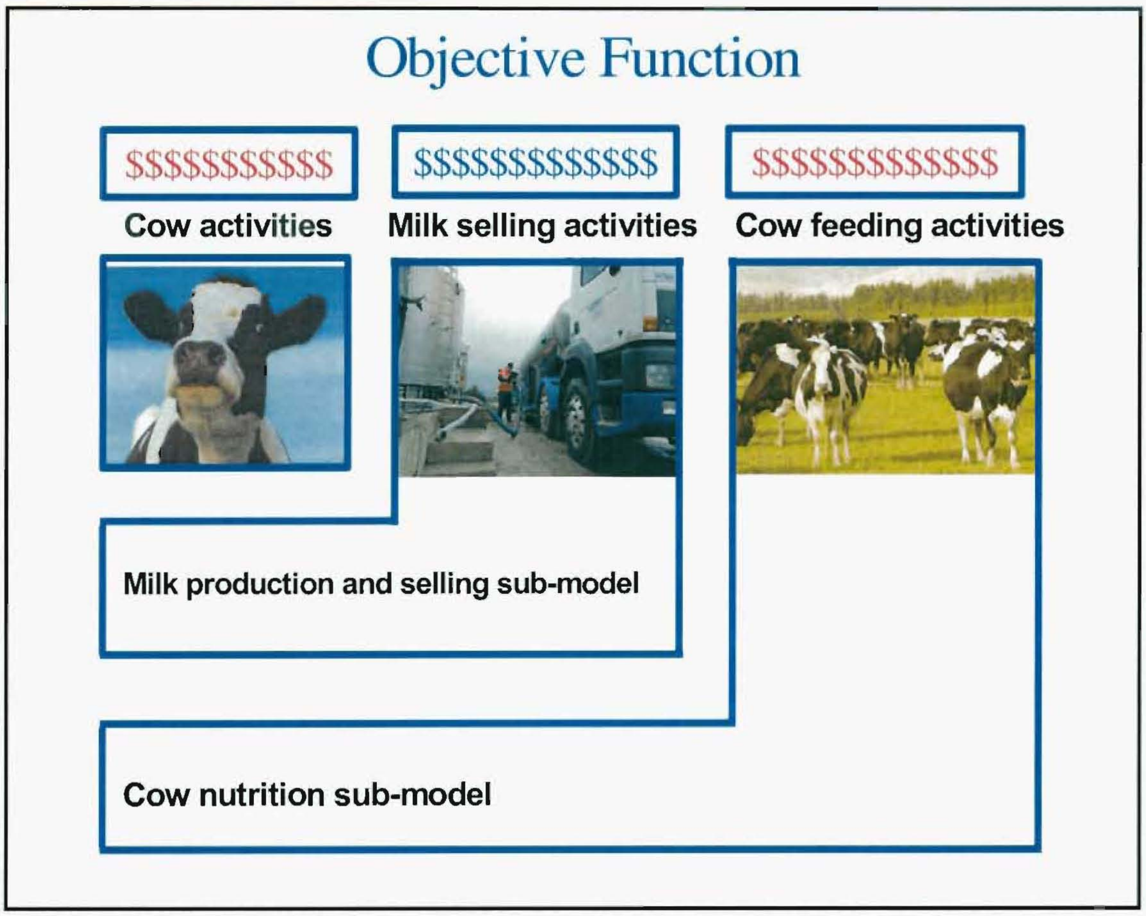

Figure 3.1: Overview of model structure

3.4.1 Objective Function

The objective function to be maximised was defined as the difference between returns from milk sales and variable costs of milk production, as represented by the following equation:

$$TGM = P_m \sum_{m=1}^{12} \sum_{k=1}^{78} D_k M^k_m - C^D \sum_{k=1}^{78} D_k - C^P A^P - C^N \sum_{t=1}^{26} N_t - C^{PS} \sum_{i=1}^{26} \sum_{t=1}^{26} A^{PS}_{i,t}$$

$$- C^{BPS} T^{BPS} - C^{BG} T^{BG} - C^{WCCS} T^{WCCS} - C^{GrO} \sum_{k=1}^{78} D_{kGrO}$$

Where

TGM	=	Total Gross Margin;
P_m	=	price of milk supplied in month m (\$/kg MS);
D_k	=	number of cows from the k*th* cow activity; (k = 1, 2, ... 78)
M^k_m	=	milk produced by a cow from the k*th* cow activity in month m (kg MS);
C^D	=	annual variable costs per cow (\$);
C^P	=	annual pasture maintenance costs (\$/ha);
A^P	=	area of pasture (ha);
C^N	=	cost of N fertilizer (\$/kg N)
N_t	=	N fertilizer applied in period t (kg);
C^{PS}	=	cost of ensiling pasture (\$/ha);
$A^{PS}_{i,t}$	=	area of pasture ensiled in period t, which was not grazed since period i;
C^{BPS}	=	cost of bought in pasture silage (\$/kg DM);
T^{BPS}	=	amount of bought in pasture silage (kg DM);
C^{BG}	=	cost of bought in barley grain (\$/kg DM);
T^{BG}	=	amount of bought in barley grain (kg DM);
C^{WCCS}	=	cost of bought in whole crop cereal silage (\$/kg DM);
T^{WCCS}	=	amount of bought in whole crop cereal silage (kg DM);
C^{GrO}	=	cost of grazing off during the dry period (\$/cow)
D_{kGrO}	=	number of cows from the k*th* herd that are grazed off during the dry period

3.4.2 Cow Activities

The model includes a number of cow activities which represent farm management practices aimed at smoothing milk supply curves. Thus, dairy farmers could increase the proportion of milk supplied outside the peak months not only by changing calving dates, but also by modifying productive parameters such as the feeding level (milk yield) and the lactation length. Some authors have suggested that increasing lactation length and MS yield per cow by feeding the cows better would increase both farmers returns and the amount of milk supplied at the shoulders of the season, thus reducing the seasonality of milk production (Edwards and Parker, 1994; Lean et al, 1996). Trial results have confirmed that manipulating the time of calving is a potential tool for reducing the seasonality of milk production in New Zealand (Auldist *et al.*, 1997; Garcia *et al.*, 1998; Auldist *et al.*, 2002).

Different combinations of these elements give rise to a wide range of options, with the associated milk supply patterns, milk production levels, and nutritional requirements. The cow activities were specified by combining the following parameters: calving date, lactation length, and MS production per lactation. To simplify the model, the combinations were limited such that both typical and achievable situations in the South Island could be represented with a minimum of cow activities. The information needed to accomplish this was obtained from consultants, farmers, and LIC Dairy Statistics reports. The parameters assumed for specifying the cow activities are shown in table 3.1.

A model, developed by Brooks (1993), which predicts a cow's lactation and liveweight pattern for a given lactation length, milk production level, and condition score (CS) at calving, was used to specify the proposed cow activities. This information was then used to calculate the nutritional requirements of the cow activities included in the model.

Milk production, liveweight, condition score, and feed intake are interdependent aspects of dairy cow functioning (Miller, 1982). If body reserves are low at the beginning of lactation, milk production will suffer, because a greater proportion of nutrients will be directed towards replenishing reserves than towards milk production (ARC, 1980; NRC, 2001; Edwards & Parker, 1994; Lean *et al.*, 1996; Macdonald & Penno, 1998; Roche, 2001). Therefore, the potential efficiency of feed utilization for milk production is determined at the start of each lactation, and a good feeding scheme will recognize cow body condition at calving as a cardinal point in the lactation cycle. Farm management consultants and scientists, based on research carried out in New Zealand on cow nutrition, recommend a condition score (CS) of 5 at calving (Macdonald & Penno, 1998). Accordingly, a CS of 5 at calving was assumed for the entire range of cow activities included in the proposed model. The model includes 78 cow activities.

Table 3.1: Parameters that were combined to specify the cow activities included in the model.

Calving Date	Lactation Length (days)	Milk Production (kg MS/lactation)
July 1		
July 15		
July 29		
August 12		
August 26		
September 9		
September 23		
October 7		
October 21		
November 4		
November 18	270	370
December 2		
December 16		
December 30		400
January 13	300	
January 27		
February 10		430
February 24		
March 10		
March 24		
April 7		
April 21		
May 5		
May19		
Jun 2		
Jun 16		

As an example, the lactation and liveweight patterns corresponding to a cow calving on 12 August, with a lactation length of 270 days, milk production of 370 kg MS per lactation, and condition score (CS) of 5 at calving is presented in Figure 3.2. This cow is intended to serve as a base for comparisons with more intensive systems.

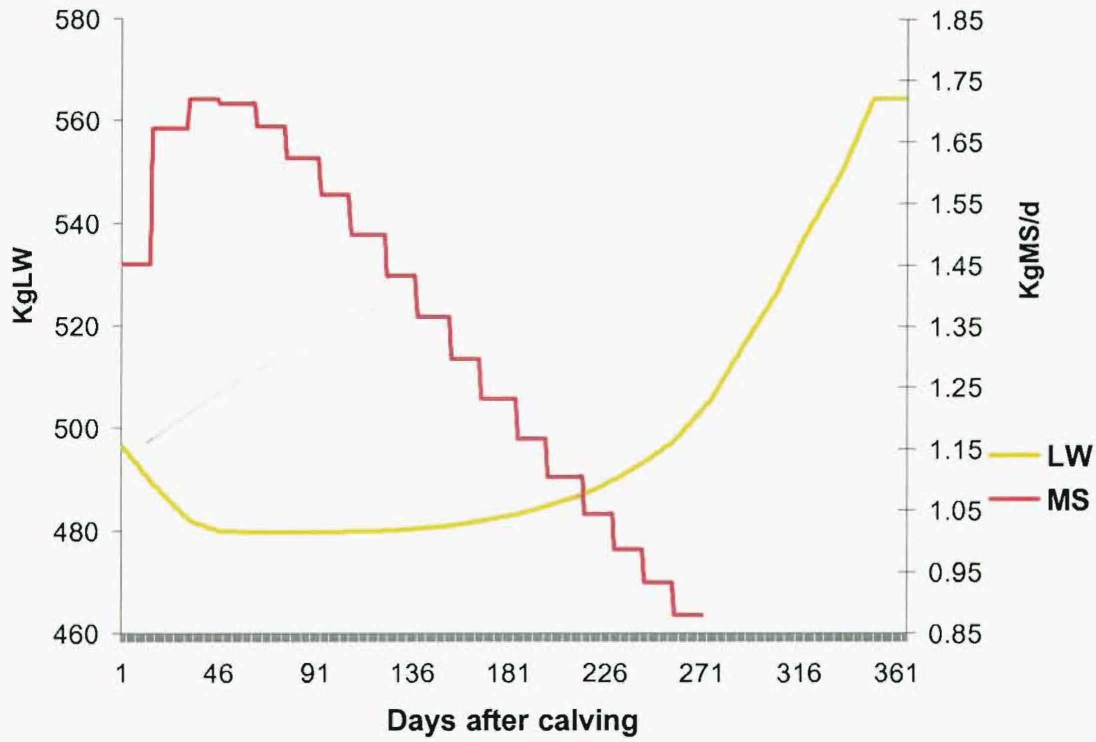

Figure 3.2: Lactation curve and liveweight change pattern of a cow calving on 12 August, with a lactation length of 270 days, and producing 370kgMS per lactation.

3.4.3 Milk Production and Selling Sub-model

Several studies have shown that calving date has a major influence on the pattern of milk production (Auldist *et al.*, 1997; Eichler, 1996; Pinares & Holmes, 1996; Garcia *et al.*, 1998). Nutritional factors have been identified as the main reason for such influence. For instance, Garcia *et al.* (1998), who compared three dairy production systems involving cows calving at different times of the year, found that autumn-calving cows had longer lactations and higher milk production levels than spring-calving cows. Although the spring calvers made relatively better use of the seasonal pattern of pasture growth than the autumn calvers through grazing the highest quality pasture during early lactation, they were also more limited during late lactation, which coincided with the lower pasture availability and quality, characteristic of late summer and early autumn. Autumn-calving cows, on the other hand, had the highest quality spring pasture during late lactation and, thus, were able to extend their lactation at higher levels of milk production than spring-calving cows. This evidence suggests that the shorter lactations of spring-calving cows could be prevented by supplying extra feed during late lactation (Pinares & Holmes, 1996). This inference is supported by the results of a study conducted by Auldist *et al.* (1997), who found that the decline in production after peak was more attributable to nutritional factors than to calving dates.

In light of the above findings, and to simplify the specification of the cow activities, the lactation curves for a given lactation length and level of milk production, were assumed to be the same for any calving date. The formulation of the model ensures that cows are provided sufficient nutrients to achieve the specified lactation levels.

Milk production and selling relationships were represented on a monthly basis, as one of the objectives of this study was to explore monthly price incentives. Pricing schemes involving shorter periods were not considered as they are unlikely to be implemented in New Zealand. A schematic representation of this sub-model is shown in Figure 3.3.

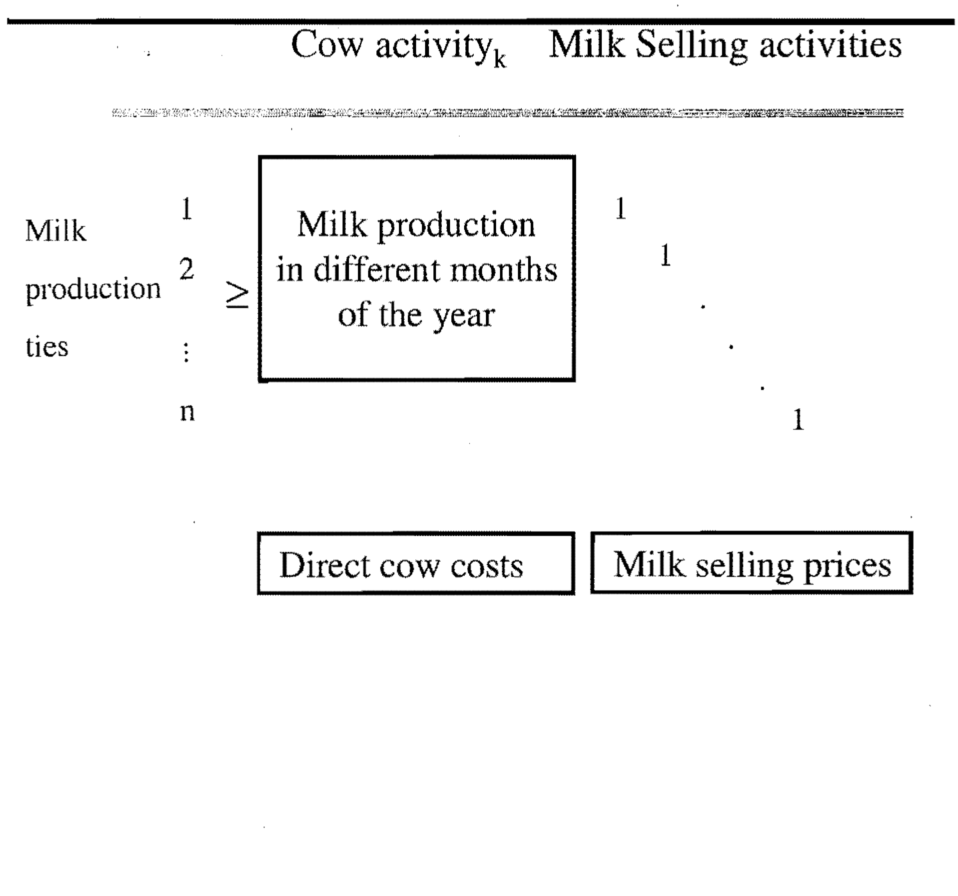

Figure 3.3: Schematic representation of the milk production and selling sub-model

3.4.4 Cow Nutrition Sub-model

An accurate model of dairy cow nutrition should ensure that cows are fed sufficient quantities of appropriate rations so that nutrient requirements, for the specified levels of performance, are satisfied within dry matter intake (DMI) limits (Miller, 1982). The nutritional sub-model comprises both a feed demand (i.e. nutritional requirements) and a feed supply component, with feed management activities linking feed supply and consumption. It is assumed that all replacements are grazed off the farm; dry cows are allowed either to be grazed on the farm, thus competing with milking cows for pasture, or to be grazed off the farm. Dry cows kept on the farm are allowed to be fed with hay. However, hay is not an option for feeding cows in lactation, due to its low energy density.

3.4.4.1 Feed Demand Component

Research has shown that energy intake is the limiting factor on milk production from cows grazing high quality pastures. For instance, Penno *et al.* (1998) conducted an experiment designed to determine the effect of season and stage of lactation on the response of pasture-fed dairy cows to supplementary feeds (rolled maize grain and a nutritionally balanced supplement). They found that neither the stage of lactation, nor the form of supplement had any effect on the milksolids response. This result suggests that the milksolids response to supplementary feeding was determined by the extent supplementary feeding increased total ME intake. Thus, it is not surprising that responses to supplementary feeding are usually expressed as g MS/MJME (Penno *et al.*, 1998; Penno *et al.*, 1999; Neaves, 1996; Penno *et al.*, 2001).

Because of the generally high protein content of New Zealand dairy pastures (24-28% crude protein) (Kolver, 1999), previous modelling studies did not consider the protein requirements of lactating dairy cows. In such studies, both the nutritional requirements of dairy cows and the nutritional values of pasture and other forages have in general been expressed in terms of pasture equivalent dry matter (see, for example, Mendizabal, 1991; Bramwell *et al.*, 1993; Gray *et al.*, 1994; McCall *et al.*, 1999). This was done probably on the assumption that supplementary feeds of low protein content would be fed either in small amounts with pasture, or at a time of the lactation cycle when protein requirements are generally low. Since this study will consider a range of supplementary feeds as potential production feeds, such an assumption is not warranted. Macdonald et al (1998) investigated the ability of urea, soybean meal, and fishmeal to overcome protein deficiencies that occurred when cows were supplemented with large amounts (> 30% of the diet) of maize silage. Fishmeal and soybean meal increased both MS yield and liveweight gain in the summer and autumn. This suggests that these supplements could have provided more protein for milk synthesis. This work showed that when feeding low-protein supplements as a large proportion of the diet, rectifying protein deficiencies is warranted. Based on the above discussion, explicit representation of protein requirements by lactating cows and protein content of all feeds were also included in the model.

Following Miller (1982), energy demand and supply relationships were expressed in terms of megajoules of metabolisable energy (MJME), whereas protein demand and supply were defined in terms of kg crude protein (CP). In addition, to ensure that energy and protein requirements were met within dry matter intake limits, and to make allowance for intake substitution of grazed pasture when supplements are fed, the maximum per cow intake of DM was defined for each period of the year. ME and CP requirements of lactating cows, as well as DMI limits, were calculated for each sub-period *t*, based on relevant publications (ARC, 1980; NRC, 1989; Holmes *et al.* 2002). These calculations are shown in Appendix A. A schematic representation of the cow nutrition sub-model is shown in Figure 3.4.

			Cow activity$_k$	Feed option$_x$
DMI$_t$	0	$\leq$	$\mathbf{r}_{\mathbf{tk}}$	-1
ME$_t$	0	$\geq$	$\mathbf{r}_{\mathbf{tk}}$	- $\mathbf{r}_{\mathbf{tx}}$
CP$_t$	0	$\geq$	$\mathbf{r}_{\mathbf{tk}}$	- $\mathbf{r}_{\mathbf{tx}}$
			Direct cow costs	Feed costs

DMI = dry matter intake; ME = metabolisable energy; CP = crude protein

Figure 3.4: Schematic representation of the cow nutrition sub-model

Energy demand and supply relationships related to dry cows were expressed in terms of megajoules of metabolisable energy (MJME). The calculations of ME requirements are shown in Appendix A. Protein requirements were not considered, since protein is unlikely to be a limiting nutrient in the ration of dry cows under New Zealand conditions. The dry cow nutrition tableau is shown in table 3.2.

Table 3.2 : Dry cow nutrition tableau

		Run Cow k (1 cow)	Pasture (ha)	Graze on dry cow k (1 cow)	Graze off dry cow k (1 cow)	Buy Hay (kg DM)	Feed hay to dry cow k (kg DM)		
ME dry period Cow k (MJ)		r		-r	-r		-r	≤	0
Pasture Reconciliation Rows (kg DM)	t-1		-r	r				≤	0
	t		-r	r				≤	0
	t+1		-r	r				≤	0
Hay reconciliation Row (kg DM)						-1	1	≤	0
					Grazing off cost	Hay cost			

Each cow activity requires a ME reconciliation row, which represents the aggregated ME requirement over the entire dry period. This requirement can be met either by grazing the cow on the farm (thus consuming pasture at the appropriate sub-periods) or by grazing the cow off the farm, at a cost. The home grazing option incurs an opportunity cost, which arises due to the consumption of pasture that could otherwise have been eaten by milking cows. Hay is also an option. Given this formulation, the energy requirements of a dry cow can be met by various combinations of grazing on, grazing off, and hay. Other supplements, such as pasture silage, could have been included in the dry cow nutrition tableau. To limit matrix size, however, hay was assumed to represent all supplements. The hay reconciliation row ensures that the amount of hay fed over the year is not more than that purchased.

3.4.4.2 Feed Supply Component

The feed supply component includes grazed pasture, N -boosted pasture, pasture conserved as silage, and bought-in supplements available in the South Island. The real-life process of transferring feed from one period to the next was simulated by means of feed transfer activities, thus permitting stored feed to be fed out in different periods and the system to be modelled achieving feed equilibrium; that is, feed inventories at the start and end of the year are the same, by transferring feed from period 26 back into period 1.

(i) Grazed Pasture

The model includes 26 pasture-grazing activities expressed in kg dry matter of pasture consumed by direct grazing in the t^{th} sub-period. These activities transfer pasture dry matter, with its time-specific contents of metabolisable energy and crude protein, to the respective nutritional rows that are common to all feeds. Surplus pasture was allowed to be saved *in situ* by means of pasture transfer activities. No published work was found as to losses associated with *in situ* pasture transfer at various times of the year. Upon consultation with experts, *in situ* pasture transfer was limited to two fortnightly periods, with assumed losses of 10% per period. Thus, surplus pasture grown in period t could be transferred *in situ* up to period t+2, with a total loss of 20% (Hughes, pers. comm.).

(ii) Pasture Silage

The model allows pasture to be ensiled at certain periods of the year (i.e. October and November). Pasture area was assumed to be shut up 6 weeks before cutting for silage. During that time and for the next 2 weeks, no growth was assumed available for grazing. For the next 2 weeks (weeks 9 and 10 from shutting up), only half the normal growth was assumed. These assumptions were based on Howse *et al.* (1996). Pasture silage feeding activities transfer pasture silage dry matter, with its constant nutritive value, to the respective nutritional rows. The pasture silage reconciliation row constrains the total quantity of pasture silage fed out in various periods to be not greater than the quantity available (both made and bought-in).

(iii) Nitrogen-boosted Pasture

The model allows N fertilizer to be applied over the whole area in pasture from August through to April. Winter applications were not allowed because in the South Island very low soil temperatures during winter cause pasture responses to N application to be negligible (Ledgard, 1989), and nitrogen leaching is a major consideration.

Nitrogen fertilizer has the potential to increase pasture production as well as to change the pattern of pasture growth. Dairy farmers in the South Island have traditionally used relatively little N fertilizer, with the main source of N in the pasture coming from N fixation by white clover. However, because grass responds readily to N fertilizer, its use has increased considerably in recent years (Cameron, 1999). The environmental impact of this increase is unknown at present, although research carried out overseas indicates that it is likely to increase the nitrate concentration in groundwater above critical levels (Cameron, 1999). Based on findings from lysimeter studies carried out at Lincoln University, Di and Cameron (2000) developed a computer model to estimate critical nitrogen application rates. This model, known as NLE (Nitrogen Leaching Estimation), predicts that critical application rates for grazed pasture are 160-200 kg N/ha/year.

Research has also shown that nitrogen fertilizer is most efficiently used when applied between 20 to 40 kg N/ha per application (Legard, 1989).

Consequently, both the amount of N applied at any given period (kg/ha/application) and the total amount applied (kg N/ha/yr) were restricted to be no more than the maximum recommended levels referred to above. Thus, no more than 40 kg N/ha was allowed to be applied in any single application, whereas the total amount applied throughout the year was restricted to be no more than 200 kg N/ha.

The size of the pasture response depends on the time of N application, as well as soil, pasture, and climatic conditions (Cameron, 1999). Results from trials in the South Island show that the best responses are generally obtained in the spring, with lower responses in the autumn (Ledgard, 1989). To simplify the model the average dry matter response was assumed to be 10 kg pasture DM per kg N applied. This response was assumed spread over a 8-wk period.

Twenty-six pasture dry matter rows reconcile pasture produced (including N-boosted pasture), with pasture grazed, ensiled, and transferred in each sub-period. A schematic representation of the pasture tableau is shown in table 3.3.

Table 3.3: Schematic representation of the Pasture Tableau

			ACTIVITIES																			
			Run Cow k (1 cow)	Grow pasture (ha)	Apply Nitrogen Fertiliser (kg)			Save pasture (kg DM)			Graze pasture (kg DM)			Make pasture silage (Ha)			Buy pasture silage (kg DM)	Feed pasture silage (kg DM)				
					t-1	t	t+1	t-1	t	t+1	t-1	t	t+1	t-1	t	t+1		t-1	t	t+1		
Maximum voluntary intake rows	(kg DM)	t-1	-r								1							.7			≤	0
		t	-r									1							.7		≤	0
		t+1	-r										1							.7	≤	0
ME Reconciliation rows	(MJ)	t-1	r								-r							-r			≤	0
		t	r									-r							-r		≤	0
		t+1	r										-r							-r	≤	0
CP Reconciliation rows	(kg)	t-1	r								-r							-r			≤	0
		t	r									-r							-r		≤	0
		t+1	r										-r							-r	≤	0
Land	(ha)			1																	≤	A
Pasture Reconciliation rows	(kg DM)	t-1		-r	-r			1			1			r	r	r					≤	0
		t		-r	-r	-r		-.9	1			1		r	r	r					≤	0
		t+1		-r	-r	-r	-r		-.9	1			1		r	r					≤	0
Max N applied per application	(kg)	t-1		-r	1																≤	0
		t		-r		1															≤	0
		t+1		-r			1														≤	0
Max total N applied	(kg)			-r	1	1	1														≤	0
Pasture silage reconciliation row														-r	-r	-r	-r	1.2	1.2	1.2	≤	0

(iv) Bought-in Supplements

A wide range of supplements are available in the South Island (Macdonald, 1999; Allison, 1999). The model includes the most commonly used supplements, namely: pasture silage, whole crop cereal silage, and barley grain. A maximum constraint was set on the daily intake of grain. To avoid digestive problems, it is recommended that cows eat no more than 5 kg of grain per day (Hughes, pers. comm.). No limits were imposed on the maximum amounts of silages fed (both pasture and whole crop cereal). However, these are indirectly limited by the dry matter intake constraints, which ensure that cows are given a diet with an adequate nutrient density.

When concentrates are fed in conjunction with roughages, there is usually a depression in intake of roughage, known as the 'substitution effect', although the total dry matter intake is usually higher than when roughage alone is fed (Hulme *et al.*, 1986). According to Moran and Trigg (1985), the rate at which concentrates substitute for roughage increases with the proportion of concentrate in the diet, such that:

- 0.64 kg decrease in roughage intake per kg of concentrate when concentrate comprise less than 25% of the total ration dry matter.
- 0.84 kg/kg substitution for the proportion of concentrate which comprise 25-50% of the total ration dry matter.
- 1.22 kg/kg substitution for the proportion of concentrate comprising greater than 50% of the total ration dry matter.

The above varying substitution rates were incorporated into the model through the formulation shown in table 3.4. This formulation ensures that the substitution rates apply for the appropriate fraction of concentrate in the ration. However, it was later simplified because it caused the model to be over constrained (refer to the Model Evaluation Chapter).

Table 3.4: Supplementary Feeding Tableau

			Run Cow k	Graze pasture	Buy pasture silage	Feed pasture silage	Buy whole cereal crop silage	Feed whole cereal crop silage	Buy barley grain	Feed barley grain	C1	C2	C3		
				t		t		t		t	t	t	t		
Maximum voluntary intake rows	(kg DM)	t	-r	1		1		1			.64	.84	1.22	≤	0
ME Reconciliation rows	(MJ)	t	r	-r		-r		-r		-r				≤	0
CP Reconciliation rows	(kg)	t	r	-r		-r		-r		-r				≤	0
Concentrate fraction 1	(kg)	t		-.25		-.25		-.25		-.25	1			≤	0
Concentrate fraction 2		t									−1	1		≤	0
Concentrate fraction 3		t										−1	1	≤	0
Concentrate rec. row										−1	1	1	1	=	0
Pasture silage rec. row					-1	1								≤	0
W. cereal crop rec. row							-1	1						≤	0
Barley grain rec. row									-1	1				≤	0

3.5 Summary

The model developed for this study is a deterministic linear programming model comprising 482 activities and 270 constraints. The model represents a single year production cycle divided into 26 fortnightly sub-periods. Since the system is assumed in equilibrium, feed inventories at the start and end of the year are equal, through feed-transfer activities. The model selects stocking rates, feed inputs, calving dates, lactation lengths, milk production levels and resulting patterns of milk supply that maximize the objective function.

The model comprises a milk production and selling sub-model, and a cow nutrition sub-model. These sub-models are linked by the cow activities, which are the pivotal components of the model. The structure of the milk production and selling sub-model allows simulating milk pricing schemes involving monthly price differentials that could be used to encourage out of season milk production. The cow nutrition sub-model operates like a ration formulation programme, ensuring that the cows are fed appropriate rations, so that metabolisable energy and crude protein requirements for the specified levels of performance are satisfied within dry matter intake limits. The cow activities were specified by combining the following parameters: calving date, lactation length, and MS production per lactation. To simplify the model, the combinations were limited such that both typical and achievable situations in the South Island could be represented with a minimum of cow activities

CHAPTER 4

MODEL EVALUATION

4.1 Introduction

In Chapter 3, the structure of the linear programming model developed for this research was described, and the relationships assumed for the model were discussed. This chapter contains a description of the procedures used in evaluating the model. Although these procedures were carried out during model development, for explanatory purposes they are described in a separate chapter.

Since most mathematical models are simplifications of reality and contain many assumptions, their use as predictors requires an assessment of the accuracy of their predictions. This assessment, known as model evaluation, is a continuous process aimed at building an acceptable level of confidence on the suitability of the model for making inferences about the real system being modelled.

Model evaluation is usually described in the literature as a multi-stage process comprising model verification and validation (Dent *et al.*, 1986). Model verification and validation are not so much separate stages of modelling, but continuous iterative processes involving model and sub-model formulation and testing, as shown in figure 4.1 Thus, model evaluation is an ongoing process during model development, and extends beyond it, ensuring that the model is logically sound and sufficiently realistic to provide useful answers to the questions posed.

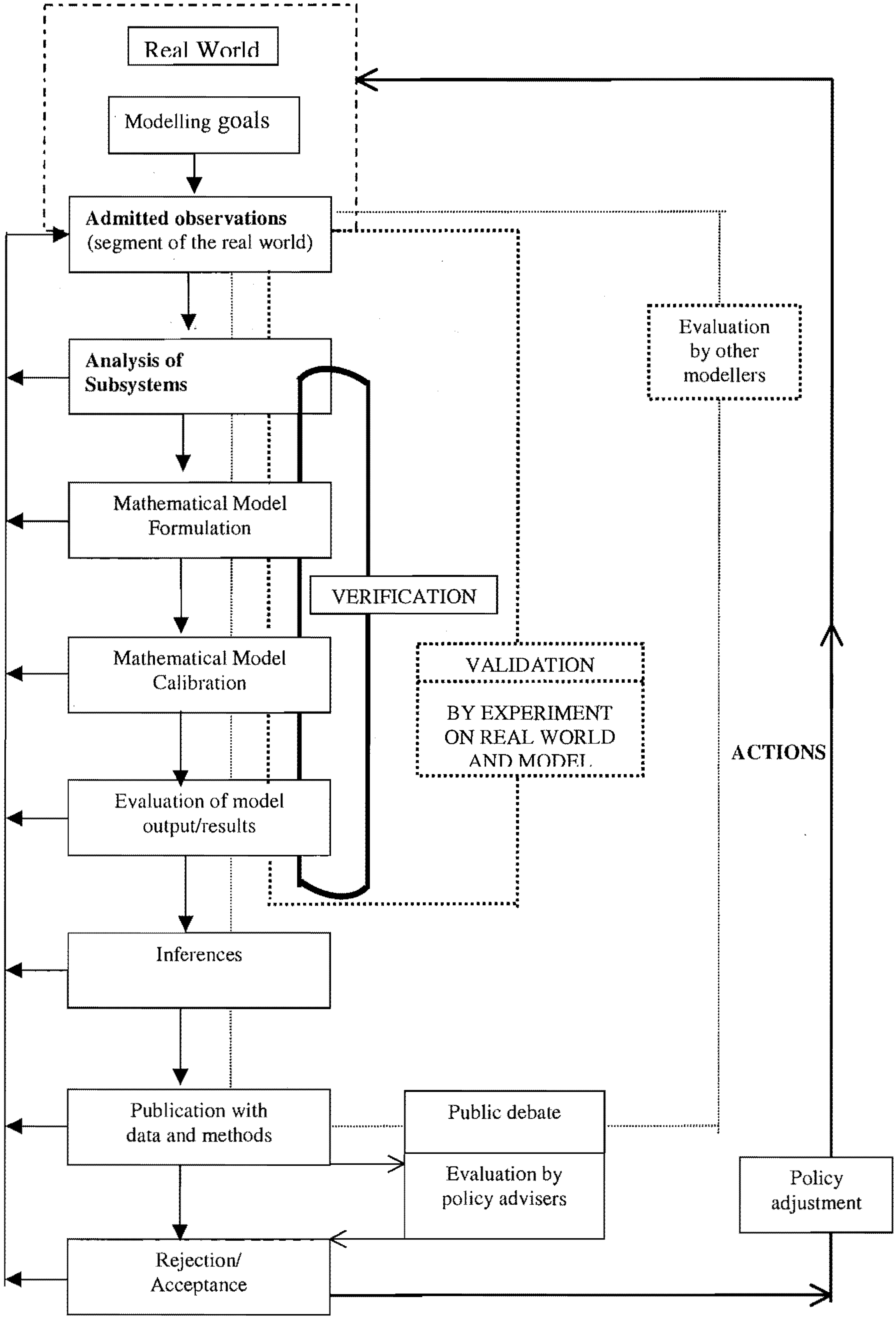

Figure 4.1: The model building process and its interaction with "the real world". (Source: Gass, 1983).

4.2 Model Verification

This process, also referred to as debugging, consists of checking the mathematical and logical correctness of the model (in this case, of the linear programming matrix), with the aim of ensuring that it is consistent with the underlying assumptions (Pannell *et al.*, 1996). Model verification involves the prevention, identification, and elimination of bugs. Bugs are errors in the structure of the model, and can be associated with the model coefficients, constraints, and activities. They are usually detected during the model development and initial runs through one of the following symptoms (Pannell *et al.*, 1996): (a) un unlikely model solution, (b) no feasible solution, or (c) an unbounded solution.

Infeasible or unbounded solutions will be clearly indicated in the output from the computer program, but identification of unlikely solutions requires a degree of subjective judgement (McCarl and Apland, 1986). Thus, an unlikely solution may be either obvious or very subtle, and may involve one of the elements of the solution being outside the expected range. The suspect element may be the level of an activity, the dual price of an activity, the level of slack for a constraint, or the shadow price for a constraint (Pannell *et al.*, 1996). These values can be used to not only find and correct bugs, but also to calibrate the model.

During the construction of the linear programming matrix, the model was run many times as a means of preliminary verification. The checks at this stage were aimed at determining if the parameters were rational and that model logic was as intended. The verification procedure identified needed corrections in the data or model structure, such as faulty calculations and coefficient placement.

Some initial results were found to be infeasible or unlikely, leading to examination of the model and subsequent improvement. For instance, in an attempt to represent pasture substitution rates with great accuracy (refer to chapter on model development), the model apparently became over-constrained, leading to unlikely solutions (such as running no cows at all!). When a constraint was imposed to run at least one cow, the solution was infeasible. As a result, the model structure was simplified by eliminating unnecessary constraints and incorrect technical assumptions. The errors most frequently found were coefficients with the wrong sign, constraints operating in the wrong direction, and coefficients placed in the wrong place in the matrix.

Bugs were dealt with in two ways. One was to detect them through the obvious symptoms and through careful examination of the model's coefficients. The other was to prevent them occurring in the first place. This was done by means of discipline and care, and by following the bug-prevention strategies suggested by Pannell *et al.* (1996), namely:

(a) Model development was meticulously documented, and carried out in small steps. Thus, each version of the model was thoroughly tested and debugged before adding the next component or the next level of complexity.

(b) When entering data, it is preferable to use a matrix editor rather than a text editor. Unfortunately, the LP package used during this study (LINDO) did not include a matrix editor. Therefore, each version of the model was first constructed in matrix form using a computer spreadsheet, and then entered into the LP package in algebraic form, using the LINDO built-in text editor. This undoubtedly increased the risk of introducing typing errors. On the other hand, LINDO has some features for checking the specification of rows and columns. Thus, it was possible to view one or more rows or columns on the computer terminal, and since only non-zero values were shown, the whole matrix could be rapidly checked. The corrections, however, could not be directly implemented within the matrix, but had to be entered through the text editor. This made the debugging process rather cumbersome.

(c) Only one master copy of the matrix to which changes could be made was maintained. This prevented bugs, which had been previously fixed, from returning.

(d) A meaningful and consistent system for naming rows and constraints was implemented. A legend was included in the model documentation.

(e) Intuitively obvious units of measurement for rows and columns were used, which were recorded within the legend of row and column names.

(f) The structure of the matrix was designed so as to group related rows and columns together. This order was consistently used so that the visual pattern of coefficients could help highlight a coefficient out of place or with the wrong sign.

4.3 Model Validation

Validation or evaluation of model behaviour involves testing whether the model is adequate for analysing the problem being investigated and thus accomplishing the objective/s of the research being carried out (Anderson, 1974). Whereas verification can be measured in absolute terms, validation can only be assessed relative to specified study objectives (Dent *et al.*, 1986). Thus, the latter is much more subjective than the former and is an ongoing process of assessing whether the model structure is sufficiently realistic to provide useful answers to the posed questions, and whether the results appear reasonable in relation to expectations (Dent *et al.*, 1986).

Despite the subjectivity underlying the validation process, a systematic approach to model validation allows a semi-objective evaluation of the strengths and weaknesses of a model. The model was validated using such an approach, referred to as "validation by results" (McCarl and Apland, 1986). Validation by results consists of a comparison of model solutions with corresponding real world outcomes, to determine whether there is a sufficient relationship between modelled behaviour and observed behaviour. Such a validation procedure assesses the predictive capability of the model.

The output of a linear programming model consists of at least three items: the optimal values of the primal decision variables, the dual variables, and the objective function. All of these need to be systematically validated in order to assess a LP model. However, the least important item is the objective function value as it will be correct if the other items are correct (McCarl and Apland, 1986). Thus, validation was taken to include many aspects of a solution: stocking rates, calving patterns, feeding patterns, lactation patterns, total gross margin and row shadow prices (in particular those of energy and pasture dry matter rows).

Six steps were undertaken in validating the linear programming model used in this study, namely:

(i) A list of model assumptions and parameters were presented to agricultural scientists, experts in dairy production, consultants, and dairy farmers, who assessed the accuracy and correctness of such assumptions and parameters.

(ii) A set of observed outcomes was gathered from the case study farm.

(iii) A validation experiment was selected.

(iv) The experiment was applied to the model.

(v) The degree of association was tested.

(vi) Finally, a decision was made regarding the validity of the model

Two types of experiments were applied to the model, namely partial tests, and prediction experiments (McCarl and Apland, 1986).

Partial tests were used to validate portions of the model. Thus, the model was run with some of the variables fixed at real world levels, with other variables left unconstrained. For instance, this procedure was used to isolate the pasture production and consumption sub-model, which is a core component of the model. Hence, the amounts of supplementary feeds, including nitrogen fertilizer application, were fixed at the levels observed in the case study farm. Stocking rate was considered the key variable.

The model output initially revealed a much lower stocking rate than that observed in the case study farm (2.4 vs 2.6 cows/ha), with an assumed pasture utilisation rate of 75%. Since the pasture feeding activities were the only unconstrained feeding activities, it was evident that the pasture utilisation rates assumed had been understated, causing the very low stocking rate in the model solution. Thus, these utilisation coefficients were increased gradually and the model re-run, until the stocking rate suggested by the model and that observed in the case study farm were similar. This occurred at a pasture utilisation rate of 85% in all sub-periods. This way, the model was "calibrated." Table 4.1 shows the comparison of case study farm and model plans after the calibration procedure.

Table 4.1: Comparison of constrained model and case study farm plans

	Model	Case Farm
Number of cows	450	450
Stocking rate (cows/ha)	2.65	2.65
Lactation length (days)	300	287
MS production per cow (kg)	430	428
MS production per ha (kg)	1140	1134
Bought-in pasture silage (kg)	213150*	213150
Barley grain (kg)	72184*	72184
N fertilizer (kg/ha)	114*	114

* Fixed

This exercise gave confidence on the adequacy of the model to predict the nutritional requirements of the cow activities included in the model. In addition, it confirmed that the nutritional value of the feeds considered (i.e. pasture and supplements) were reasonably accurate.

The supplementary feeding activities were then unconstrained to conduct a prediction experiment. The prediction experiment is the most commonly used experiment for validating linear programming models by results (McCarl and Apland, 1986). It represents an attempt to determine whether the model can replicate agent or system behaviour that has been observed. Thus, it is the ultimate test of the model's ability to replicate reality. The result of this test is shown in table 4.2.

Table 4.2: Comparison of unconstrained model and case study farm plans

	Model	Case Farm
Number of cows	446	450
Stocking rate (cows/ha)	2.62	2.65
Mean calving date	26 Aug	22 Aug
Lactation length (days)	300	287
MS production per cow (kg)	430	428
MS production per ha (kg)	1127	1134
Supplements used		
Bought-in pasture silage (kg)	61783	213150
Barley grain (kg)	43431	72184
Total	105214	285334
Total supp./cow (kg)	236	634
Total supp./ha (kg)	619	1678
N fertilizer (kg/ha)	200	114
GM ($)	492,000[1]	460,000

[1] Since the case study farmer uses a run off to graze off dry stock, at very cheap rates, the grazing off costs assumed in the model have been added back to the GM of the optimal plan, to make a fairer comparison between the GM of both plans (Total grazing off costs of the plan generated by the model sum to $80,280).

As shown in table 4.2, both the stocking rate and the level of MS production (per cow and per ha) predicted by the model were very close to those observed in the case study farm. This level of milk production is much higher than that observed in an average Canterbury farm (350 kg MS/cow, 2001/2002 season) (Dairy Monitoring Report, 2002). The model, however, prescribed a slightly later mean calving date (26 August vs. 22 August).

Although the model predicted that it was most profitable to have well fed cows at relatively low stocking rates[2], it chose a different way of meeting the nutritional requirements of the cows. Hence, it prescribed a higher reliance on nitrogen-boosted pasture, and less use of bought-in supplements. This solution seemed intuitively reasonable, since pasture is by far the cheapest source of feed. Thus, it would be more profitable to attempt to boost pasture growth before making heavy use of the more expensive feedstuffs. Figure 4.2 depicts the feeding pattern predicted by the model, whereas figure 4.3 shows the feeding pattern observed in the case study farm.

For a model to be valid, however, it is not required that it reflect reality in all aspects (Wright, 1971). According to Gass (1983), a model is predictively valid if it matches data acquired from the real system, whereas it is structurally valid if it not only reproduces the observed real system behaviour, but also reflects the way in which the real system operates to produce such behaviour. The comparisons shown in table 4.2 and figures 4.2 and 4.3 suggest that the model can be considered predictively valid, but not structurally valid, because it does not reflect the feeding pattern observed in the case study farm. However, the diet composition used in the case study farm may not be optimal, as suggested by the GM of the model solution, which is approximately 7% higher than that of the case study farm.

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[2] The average Canterbury dairy farm had a stocking rate of 3 cows/ha in the 2001/2002 season. The forecasted stocking rate for the 2002/2003 season is also 3 cows/ha (Dairy Monitoring Report, 2002).

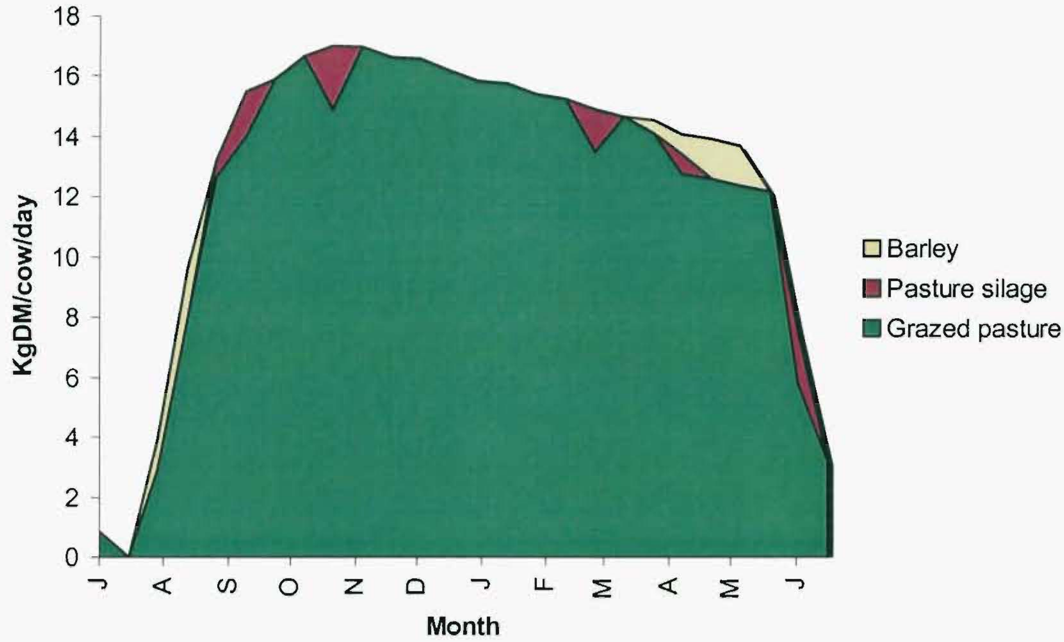


Figure 4.2: Feeding pattern predicted by the model.

Nitrogen boosted pasture included in the pasture component of the diet.

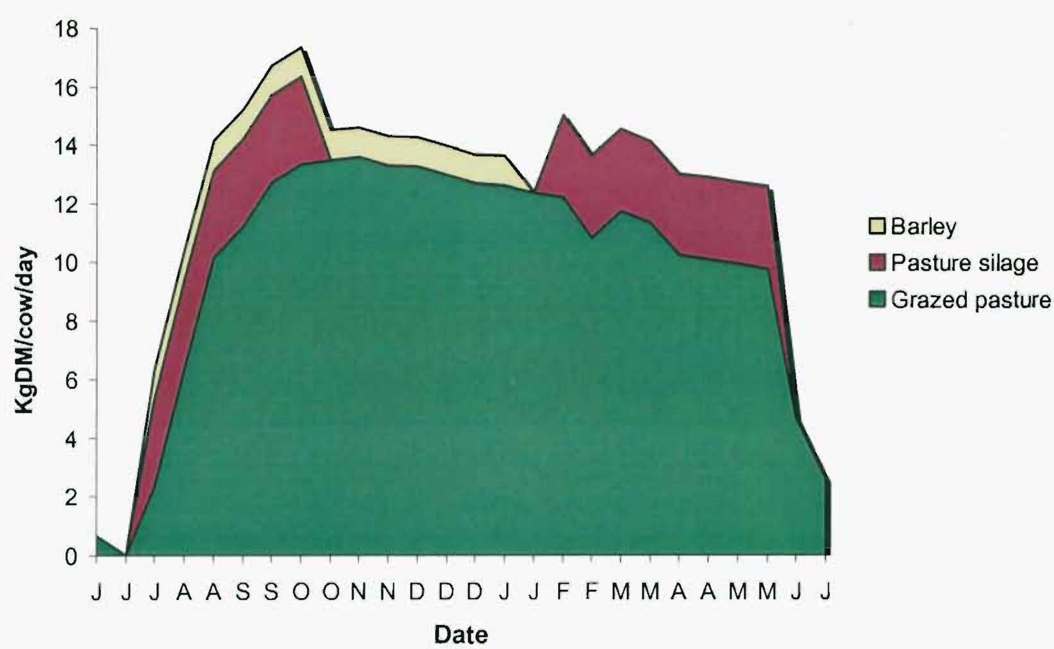


Figure 4.3: Feeding pattern observed in the case study farm.

Nitrogen boosted pasture included in the pasture component of the diet.

Figure 4.4 shows that the coefficients and relationships assumed in the milk production and selling sub-model are accurate, because the model closely predicted the milk supply pattern of the case study farm. However, the latter shows a higher peak than the curve predicted by the model, probably because the case study farm achieves the same level of milksolids production per cow with a shorter lactation (i.e. 287 vs. 300 days; see table 4.2).

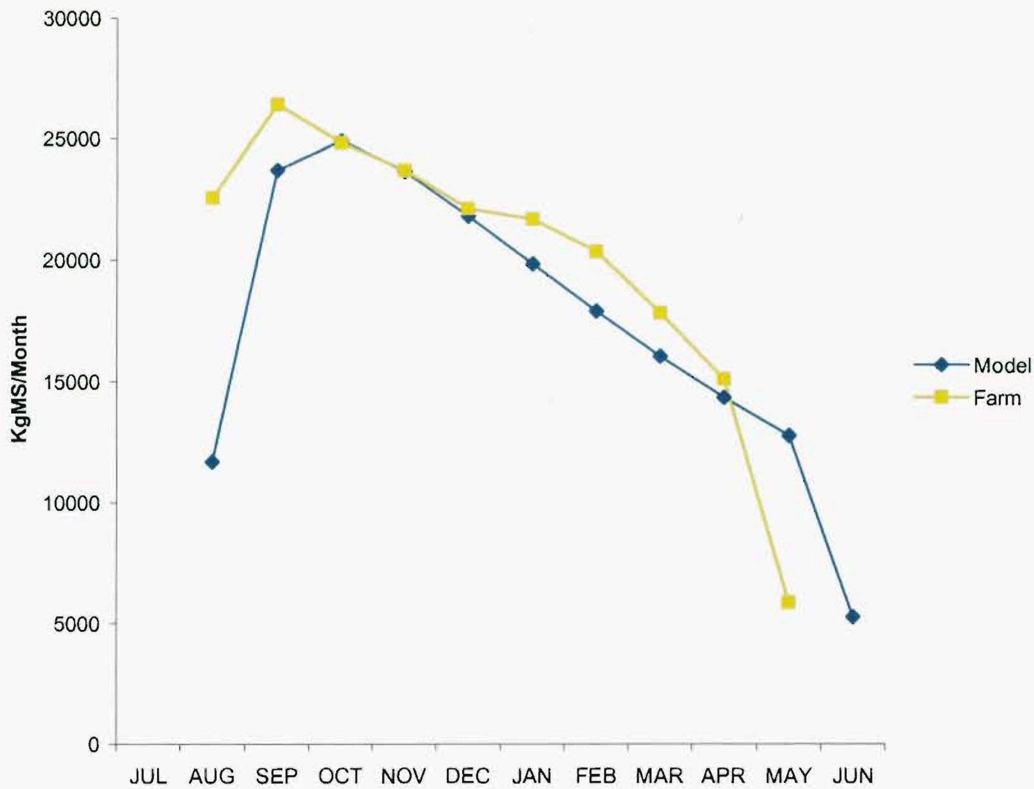


Figure 4.4: Milk supply pattern predicted by the model and observed in the case study farm

Examination of row shadow prices revealed that the model required further calibration. For instance, the shadow prices of both energy and dry matter intake limit rows took values that were considered unrealistically high during a certain sub-period (around calving). Roche and Reid (2002) estimated the average value of energy to be around \$0.02/MJ metabolisable energy. The shadow prices of energy reported in the model output were close to this figure throughout the year, except during calving, where the imputed value of energy reached \$0.70/MJME. During the same sub-period, the shadow price of the dry matter intake constraint was also unrealistically high. Thus, assumed pasture substitution rates when feeding concentrates were modified until the shadow prices were considered realistic. This occurred with a pasture substitution rate of 0.7 (i.e. 0.7 kg pasture DM substituted for every kg of concentrate DM eaten). Figure 4.5 shows the shadow prices of both energy and pasture DM intake rows after the calibration procedure.

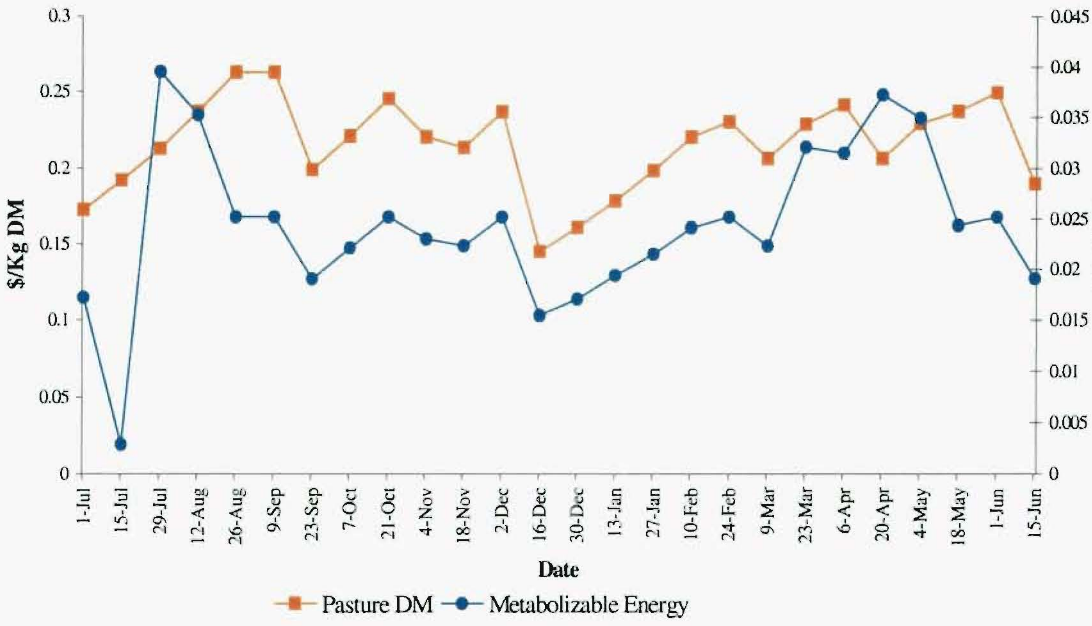


Figure 4.5: Shadow prices for ME and pasture DM rows calculated by the model

According to Grainger and Mattews (1989), about 0.7 kg of pasture DM is substituted for every kg of grain DM when cows are offered pasture for ad libitum intake. Since the model solution directs that the cows be offered high allowances of pasture, and small quantities of supplements, the use of this substitution rate seemed reasonable. However, when pasture comprises less than 60% of the cow's ration, there is little substitution of pasture by grain (Grainger and Mattews, 1989). This is likely to be the case when considering winter milk production, where the cow's diet would consist mainly of supplements. However, since the calibration procedure did not alter the optimal solution discussed previously, it was considered that this parameter was not critical, and thus, the assumed substitution rate of 0.7 was judged valid.

4.4 Summary

A linear programming model of a farm attempts to represent a bio-economic system as a set of linear equations. The usefulness of a model as a predictor depends on the accuracy of both the basic assumptions and the relationships specified in its construction. Thus, the model developed for this study was evaluated through verification and validation. Two types of experiments were applied to the model, namely partial tests and prediction experiments, using data from the case study farm. . It was concluded that the model was adequate for its purpose.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

Earlier chapters contained a description of the model and the procedures used to assess its adequacy for analysing the research problem. Having concluded that the model was valid for this purpose, it was used to conduct a series of experiments which were designed to accomplish the research objectives set out in Chapter 1. In this chapter, the experiments that took place are described, and the results obtained are discussed.

Experimentation proceeded in three phases. The first phase involved generating optimal plans for the case study farm under different milksolids price scenarios. The objective was to explore how the optimal plans changed as the assumed MS price increased, and to assess the implications of such changes in relation to the seasonality of milk production. These plans represented dairying systems that would be optimal under the pricing scheme currently used in New Zealand, and provided a base to compare the physical and economic characteristics of plans generated in subsequent experiments. In the second phase, the model was used to explore farming systems for spreading milk supply patterns and to calculate the costs of producing milk from these systems. Thus, systems involving split calving a herd (spring and autumn) were simulated by forcing increasing proportions of the herd to calve in autumn. These plans were then compared to the optimal plans generated in phase one. Finally, the third phase involved simulating different payment systems that could be implemented in New Zealand to reduce the seasonality of milk supply, namely, differential pricing systems involving premiums paid for milk supplied outside the peak months. By changing the milk prices in the objective function and re-running the model iteratively, it was possible to predict the farm management implications of differential pricing systems, and to estimate the premiums that would be required to encourage farmers to change their milk supply patterns. This approach is based on the assumption that farmers have the all-embracing objective of profit maximisation, which is in fact seldom the case. Thus, the conclusions must be considered in this light.

The size of the model and its sensitivity to very small changes in prices or physical coefficients required much care in the interpretation of results. Most solutions were degenerate, containing several activities in the basis at zero level, and very small price and activity ranges over which the solutions were stable. This means that there were several solutions with similar objective function values. Often, in response to small price changes, large shifts in optimal feeding policies and calving dates occurred with only minor effects on the objective function. Minas (1956) suggested that this is an inherent problem of large and complex models, since in general, precise models are built at the price of a considerable abstraction from the real system being modelled, and, conversely, rich, accurate models are generally imprecise. However, in reality there are often many practical systems, sometimes significantly different, with similar profit levels.

As each run of the model generated too much detail to be fully reproduced, the output information is presented in summarised form. The output from the computer package used also included shadow prices and stability ranges. None of this information has been presented except in special cases, because of the following reasons:

(a) the price range within which the objective function coefficient of a basic activity can vary without affecting the optimal plan only applies where the objective function coefficients of all other activities remain unchanged. In most cases, when analysing the stability of a solution with regard to price changes, it is unrealistic to assume that these prices are independent;

(b) the increase in gross margin, or reduction in cost (i.e. shadow price), necessary for a non-basic activity to become basic without affecting the value of the objective function, only applies if the objective function coefficients of all other activities remained unaltered. In most real cases, this assumption is not valid.

5.2 Optimal Plans for the Case Study Farm

5.2.1 Base Optimal Plans under Varying Milksolids Prices

The model was initially used to generate optimal plans for the pricing scheme currently used in New Zealand (i.e. the same milksolids price for every month of the year). Plans were obtained for four milksolids prices ($3, $3.6, $4.2, and $4.8/kgMS). These prices were considered to reflect the variability in milksolids prices observed in recent years (refer to Chapter 2). All other parameters were unchanged. The purpose of these initial experiments was to gain an understanding of the economics of seasonal milk production systems. Thus, the aim was that the insights obtained from these results would aid in the interpretation of the implications of developing out of season milk production systems, which are looked at in later stages. The results are summarised in table 5.1.

Table 5.1: Optimal plans for the case study farm under a range of milksolids prices

	Milksolids Price ($/kg MS)			
	3.0	**3.6**	**4.2**	**4.8**
Stocking rate (Cows/ha)	2.40	2.46	2.62	4.00
MS/cow (kg)	430	430	430	430
MS/ha (kg)	1,034	1,060	1,127	1,720
Mean calving date	26 August	26 August	26 August	26 August
Lactation length (days)	300	300	300	300
Pasture area conserved (% of pasture area)	3	2	0	0
Spring N fertilizer (kg N/ha)	74	57	88	40
Autumn N fertilizer (kg N/ha)	126	143	112	160
Total N fertilizer (kg N/ha)	*200*	*200*	*200*	*200*
Feed use:				
Grazing off (% of herd)	66	84	100	100
Grazed pasture (kg DM/ha)	12,826	13,204	13,654	13,691
Grazed pasture (kg DM/cow)	5,335	5,358	5,209	3,423
Home made pasture silage (Kg DM/cow)	58	33	0	0
Bought in pasture silage (Kg DM/cow)	0	0	139	1,816
Barley grain (Kg DM/cow)	64	64	97	39
Total bought in supplements (kg DM/cow)	64	64	236	1,855
Total Gross Margin ($/ha)	1,015	1,638	2,293	3,478
Total variable cost ($/kg MS)	2.02	2.05	2.17	2.78

As can be seen in table 5.1, as the MS price increases there is an almost directly correlated increase in optimum stocking rate and per hectare production. However, optimum production per cow does not change as the milk price is increased. Therefore, the increase in per hectare production is driven by increased stocking rate, rather than increased production per cow. It is interesting that the model selected in all plans the cows with the highest MS yields, which also have the longest lactations. This suggests that even at a low milk price it would be most profitable to have fewer well fed cows. Thus, under low MS prices, where the cows are fed almost exclusively on pasture, the optimal strategy would be to reduce the number of cows to allow the cows to be well fed, thus sustaining high yields.

Even at the lowest milk price considered ($3/kgMS) the stocking rate is high enough to use the pasture via grazing. This way, the costs and inefficiencies associated with pasture conservation are minimized, since only 3% of the farm area is conserved. Pasture conservation is reduced to 2% of the farm area when the milk price reaches $3.6/kgMS, and to 0% with milk prices of $4.2 and $4.8/kgMS.

The optimal mean calving date (26 August) remains unchanged in all plans. This date is close to the actual mean calving date observed in the South Island (28 August; Livestock Improvement Corporation, 2003). The later calving dates in the South Island in relation to the North Island are due to lower pasture growth rates during winter in the South Island (see Chapter 2).

Nitrogen fertiliser is used in all plans up to the maximum application rate allowed (200 Kg N/ha/year). Such application rates are common in the South Island (Cameron, 1999). The model uses nitrogen to reduce the seasonality of pasture production by increasing autumn and spring pasture production, as shown in Figure 5.1.

Nitrogen fertiliser is the most cost effective means of increasing feed supply. The strategic application of N at the shoulders of the season, as prescribed by the model, produces a more even pasture production curve, which is particularly beneficial to feeding cows with long lactations, as the ones included in the plans presented. The higher N application rates in the autumn relative to the spring (that occurs in all plans (see Table 5.1)) indicates that the model is using N to provide extra pasture for late lactation. Without this extra pasture, greater amounts of pasture silage would need to be made to transfer feed to the shoulders of the season in order to meet the prolonged nutritional requirements of cows with long lactations. Stocking rate would be reduced accordingly, in particular under low milksolids prices.

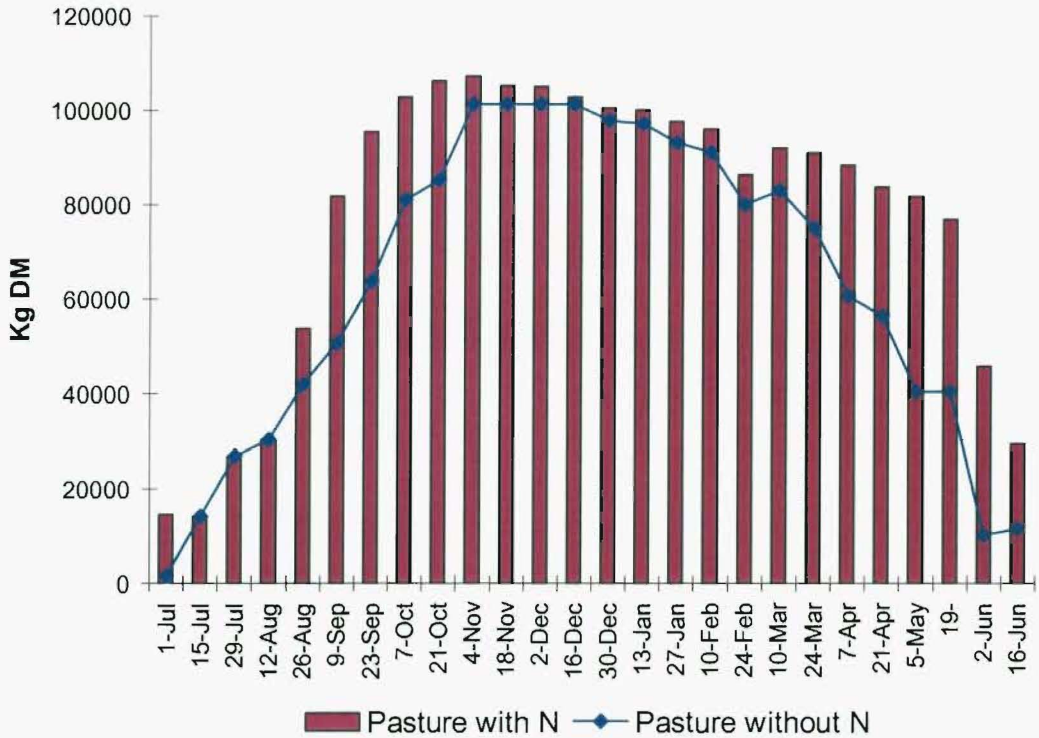


Figure 5.1: Case study farm pasture production curves predicted by the model with and without N fertiliser

As the milk price increases, the plans show increasing levels of intensification, driven by higher stocking rates. The use of purchased supplementary feed increases accordingly. Grazing off is an important source of feed in all plans, with the proportion of the herd that is grazed off the farm during the dry period increasing with higher milk prices. Thus, at \$3/kgMS, 66% of the cows are grazed off the farm; at \$3.6/kg MS this figure becomes 84% of the cows, and when the price reaches \$4.2/kgMS, 100% of the cows are grazed off the farm. This occurs because at higher milk prices, the opportunity cost of grazing dry stock on the farm becomes high enough to make grazing off a more profitable option. With 100% of the dry cows grazed off the farm, the farm becomes a milking platform, where all the pasture is grazed by lactating cows. With increasing stocking rate, the proportion of supplements (pasture silage and barley grain) in the diet of lactating cows increases, as illustrated in Figure 5.2. Thus, at \$3/KgMS supplements make approximately 2% of the cows' diet, whereas at \$4.8/KgMs, they make over 35% of the diet.

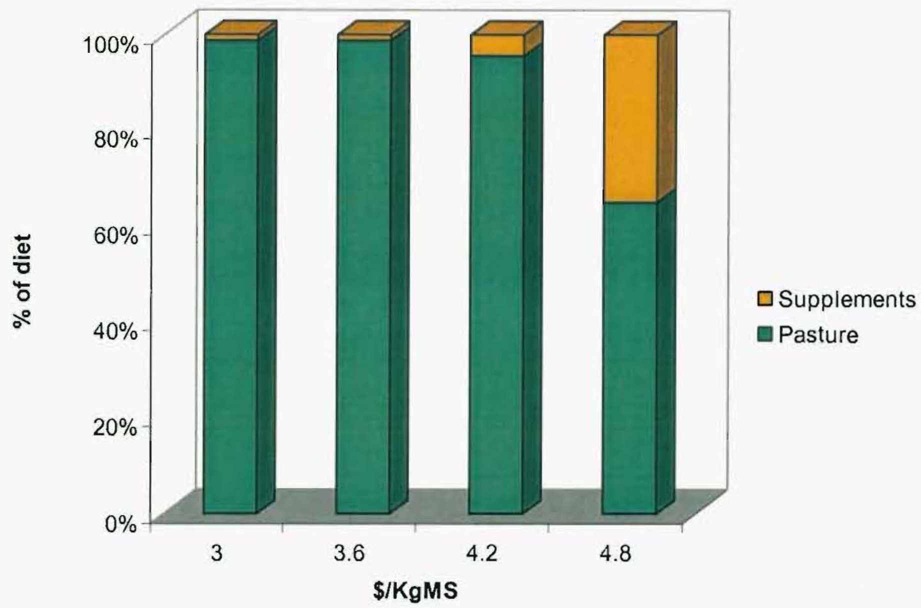


Figure 5.2: Diet composition of lactating cows under varying milksolids prices

As the milk price increases, the maximization of gross margin is coupled with a steady increase in the average cost of milk production, due to the increased use of purchased supplements. Thus, the average variable cost of producing a Kg MS increases 38% between the optimal strategies for the lowest and the highest milksolids price considered. The increase in MS production per hectare between these plans is 66%.

5.2.2 Comparison of Plans with Different Lactation Lengths

Increasing the lactation length is a plausible alternative that could be used by dairy farmers to reduce the seasonality of milk production, thus supplying more milk at the shoulders of the season. However, this practice will create feed gaps due to the increased and prolonged feed requirements of cows with longer lactations. This suggests that production costs are likely to increase and therefore, dairy farmers pursuing such a strategy would need to be compensated through price incentives.

However, the results discussed previously suggest that this may not be the case, since the model consistently predicts that, even under low MS prices, the optimal strategy would be to have cows with long lactations and, thus, higher MS yields per lactation. To explore the economic reasons for choosing a longer lactation under varying MS prices, four model runs were made to compare the base optimal plans with plans involving cows with shorter lactations and therefore lower MS yields. These tend to represent the current practice in New Zealand. The model was constrained to include only cows with short lactation lengths (270 days; 370 Kg MS per lactation), and then running the model under each of the MS prices considered. The plans generated in these runs were then compared with the optimal plans previously discussed.

The results are presented in table 5.2. For purposes of the discussion, the results corresponding to a milk price of $4.2/KgvMS are presented. However, most of the discussion also applies to the plans generated for the other prices considered. The effects of the other milk prices are discussed when appropriate. The plans obtained under the other milksolids prices considered can be found in Appendix D.

Table 5.2: Optimal plans for the case study farm involving different lactation lengths, assuming the milk price is $4.2/KgMS

	Plans	
	1*	2#
Planned start of calving	12 August	12 August
Lactation length (days)	270	300
MS/cow (kg)	370	430
MS/ha (kg)	1,057	1,120
Stocking rate (Cows/ha)	2.86	2.60
Pasture area conserved (% of pasture area)	0	0
Spring N fertilizer (kg N/ha)	67	55
Autumn N fertilizer (kg N/ha)	133	145
Total N fertilizer (kg N/ha)	*200*	*200*
Feed use:		
Grazing off (% of herd)	77	100
Grazed pasture (kg DM/ha)	13,072	13,625
Grazed pasture (kg DM/lactating cow)	4,570	5,200
Home made pasture silage (Kg DM/ lact. cow)	0	0
Bought in pasture silage (Kg DM/ lact. cow)	0	173
Barley grain (Kg DM/lact. cow)	0	64
Total bought in supplements (kg DM/l. cow)	0	237
Total Gross Margin ($/ha)	2,120	2,285
Total variable cost ($/kg MS)	2.19	2.17

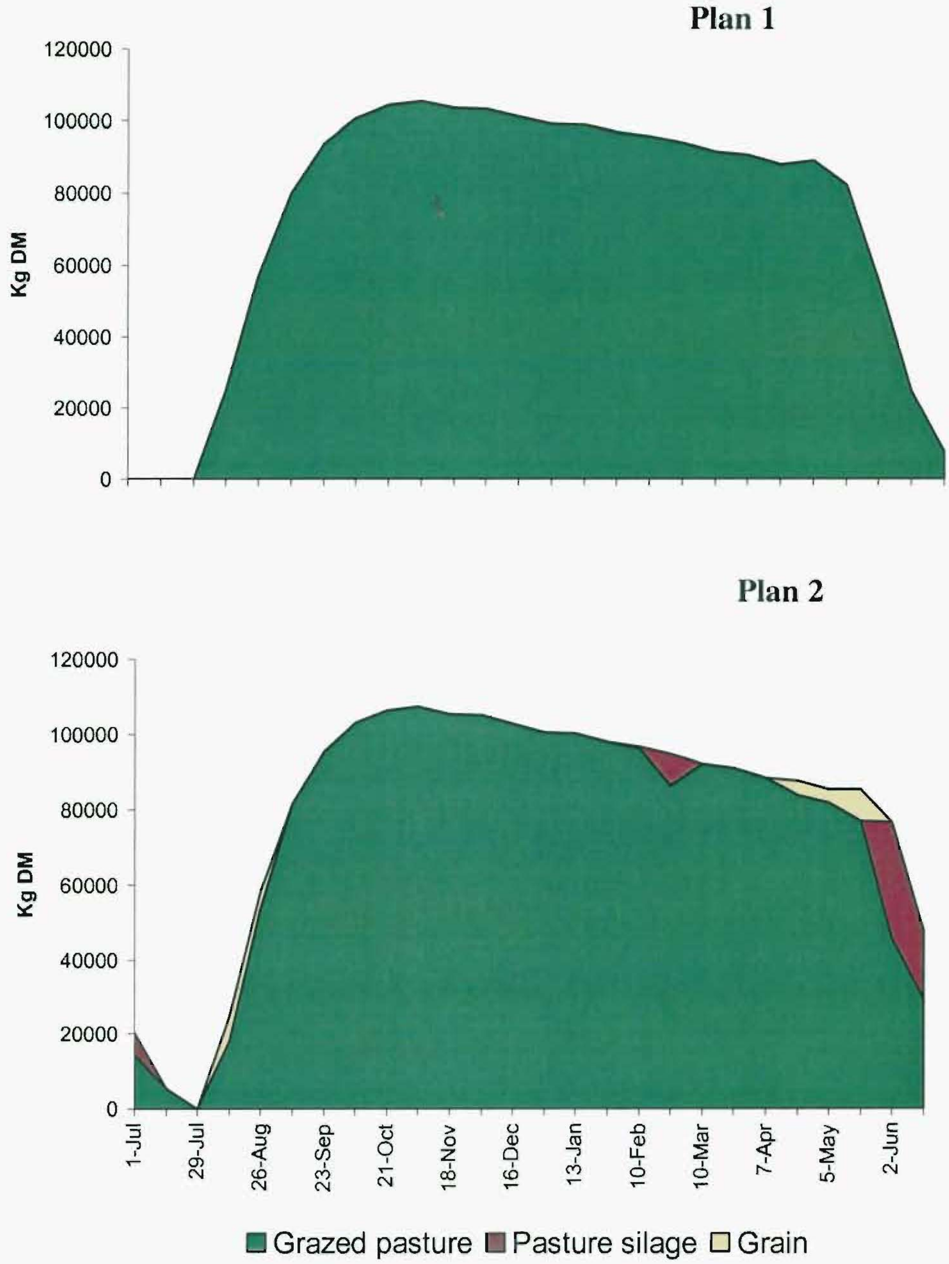
* Lactation length fixed at 270 days
# Lactation length allowed to vary – optimal was 300 days

Plan 1, although having a higher stocking rate than plan 2, has lower MS production per hectare, because of the lower MS yield per cow. Because of the short lactations and consequent lower MS yields, the diet of lactating cows consists exclusively of grazed pasture. The optimal match between pasture supply and demand maximizes the efficiency of pasture utilisation via grazing, thus avoiding the inefficiencies and costs associated with pasture conservation. However, this system is not totally self-contained for feed, since about 77% of the cows are grazed off the farm during the dry period. Nitrogen fertilizer, applied at the maximum rate allowed, also provides extra pasture. This plan is certainly a less profitable option than plan 2, which shows a 8% higher GM/ha.

Plan 2 corresponds to the optimal plan originally generated by the model and therefore, shows the highest gross margin per hectare. Compared to plan 1, this plan achieves a higher MS production per hectare, but with a lower stocking rate. In spite of the lower stocking rate, no surplus pasture is available for conservation, because of the higher pasture intake required by the cows with longer lactations. Thus, the cows included in plan 2 consume 4,446 kg of pasture DM, whereas the cows in plan 1 consume 3,885 kg of pasture DM. As 100% of the dry cows are grazed off the farm, pasture is consumed exclusively by lactating cows, converting the farm into a milking platform. Strategic use of purchased pasture silage and barley grain is made to extend the lactation. Nitrogen fertilizer also provides extra pasture during late lactation.

Figure 5.3 depicts the feeding patterns of the plans discussed above. In spite of the need to use supplementary feeds to support the increased nutritional requirements of cows with longer lactations, plan 2 achieves a lower average variable cost of producing 1 Kg MS relative to plan 1.

Extra days in milk in the latter stages of lactation are normally associated with loss of body condition and pasture cover (Holmes et al, 1994), which in turn are likely to affect next season's production. In theory, however, these losses could be prevented by giving the cows extra feed. Pinares and Holmes (1996) demonstrated the large increases in production that can be achieved by feeding silage to extend the lactation. They also identified the dangers involved. Four herds of Friesian cows were stocked at 2.9 cows/ha on separate farmlets. Two herds were dried-off on 4 April and grazed on a 71-day rotation with no silage. The other two herds were milked on until 29 May, grazed on a 16-day rotation, and fed 5.5 kg DM/cow/day as pasture silage. The milking farmlets produced an additional 57.7 kg MS/cow over the 54 days of the trial. However, these farmlets also lost 570 kg DM/ha more pasture cover than the dried-off farmlets. Further, despite the apparently generous feeding levels, the cows with longer lactations gained less condition than those with short lactations. The results of this trial suggest that there is scope for increasing milk production by extending the lactation. However, extra feed must be managed carefully to ensure that the extended lactation does not compromise next season's production.



Plan 1: Lactation length fixed at 270 days
Plan 2: Lactation length allowed to vary – optimal was 300 days

Figure 5.3: Optimal feeding patterns for plans 1 and 2 under \$3.6/kg MS

In the South Island, many farmers feed supplements during late autumn, as in the areas with reliable autumn rainfall and irrigation the cows are still producing in excess of 1.3 to 1.4 kg MS/cow in early April (Allison, 1999). These farmers, in general, find that feeding supplements to extend the lactation into April and May is a worthwhile operation. Many dairy farmers also use supplements to achieve pasture cover targets (Allison, 1999).

New Zealand dairy grazing systems have developed under the premise that the most profitable option is to maximize the amount of pasture harvested directly by grazing, thus avoiding conservation and feeding costs (Clark and Penno, 1996, Penno, 1998). As stocking rate increases, the efficiency of pasture utilization is improved, but pasture intake and milk yield per cow decline. Thus, an increasing proportion of the feed eaten is used for maintenance and pregnancy, reducing the gross efficiency of milk production (Penno, 2000). Therefore, many researchers have identified the opportunity for potential gains in efficiency from lower stocking rates and higher per cow performance (Holmes et al, 1993; Edwards & Parker, 1994; Lean et al, 1996; Penno, 1998, Penno, 1999; Kolver, 1999; McGrath, 1999; Roche, 2002; Roche & Reid, 2002). Recent research indicates that longer lactations are required to use the extra feed that results from lower stocking rates (Penno, 2000). Further, as 50% of farm working expenses are directly related to the number of cows milked (Penno, 1998), producing the same or more milk from fewer cows has the potential to increase economic efficiency (McGrath, 1999). This allows the fixed costs per Kg MS to be reduced, because fixed costs per cow are spread over a larger milk yield.

The conclusions discussed above provide further verification of the results described. That is, under all the MS prices considered, the most profitable strategy is to milk fewer cows for longer periods. Figure 5.4 summarises the results and shows that, as the milk price increases, the economic advantage of running cows with longer lactations increases.

The milk supply curves of the plans discussed are shown in Figure 5.5. The highly seasonal curve of Plan 1 represents the current situation in New Zealand, where the cows calve in early spring and are dried off in autumn, resulting in short lactations. During the peak month of October, 14% of total milk production is supplied. The supply curve of plan 2 is slightly flatter than that of plan 1, with more milk being produced at the shoulder of the season. Thus, the peak accounts for a smaller proportion of total production (13%). These results suggest that, compared to the current situation, more milk could be supplied outside the peak at no extra cost, because of the economic advantage of feeding the cows to achieve longer lactations and higher MS production.

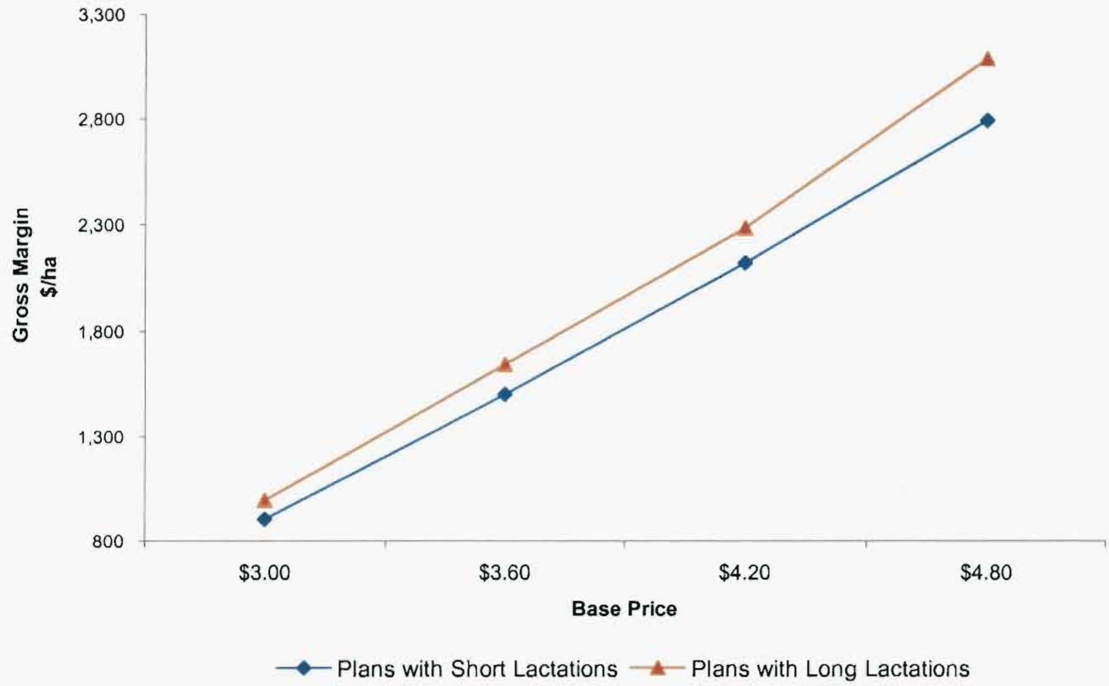


Figure 5.4: GM/ha of optimal plans under different MS prices

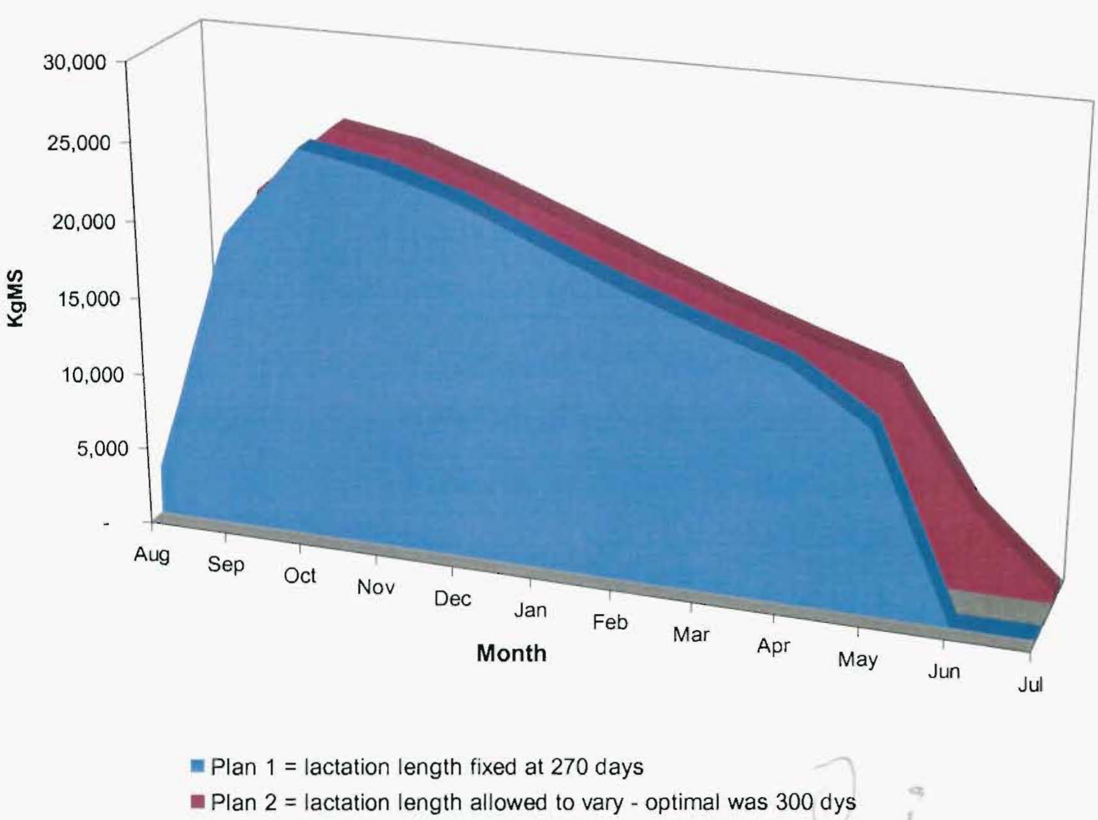


Figure 5.5: Milk Supply Curves of Plans 1 and 2

5.3 Optimal Plans for Reducing the Seasonality of Milk Production

It was apparent from the results described earlier that peak milk flows relative to total production could be slightly reduced through milking the cows for longer. Increasing milk production from fewer cows would have the overall effect of reducing average variable production costs, despite the increased use of supplements. Therefore, no premiums would be required to encourage farmers to pursue such a practice, since it would be a more profitable alternative than the traditional system involving cows with short lactations.

However, a significant reduction in the seasonality of milk production would require more drastic farm management changes than delaying drying-off, such as adopting different calving dates. Calving some, or all, of the cows during autumn is an alternative to produce more milk outside the peak. However, these systems will incur extra production costs as they will involve milking the cows during the most difficult periods of the year. This was recognized for many years in the town milk payments for quota milk averaging about 45% higher gross returns than seasonal production payouts, and with the highest premiums being paid during the difficult winter months (Stewart, 1988). The differences were necessary to cover the difficulty of feeding milking cows adequately during winter.

Systems involving split calving (spring and autumn) were simulated by forcing increasing proportions of the herd to calve in autumn and then re-running the model iteratively, under varying MS prices. In these experiments, spring calving was considered to begin on 12th August, and autumn calving on 7th April, with a 8 week spread from these dates.

The plans obtained under MS prices of $3 and $3.6 /kg MS followed similar patterns, such as decreasing stocking rates and increasing pasture conservation as the proportion of the herd calving in autumn increased. Also, plans generated for prices of $4.2 and $4.8 /kg MS had in common an increasing stocking rate as autumn calving increased, and the absence of pasture conservation in all plans. Hence, to simplify the discussion, only the plans under prices of $3.6 and $4.2 are discussed in this section. Full details of the plans obtained under all milksolids prices considered are included in Appendix D.

5.3.1 Plans under a Milksolids Price of \$3.6/kg MS

These plans are summarised in Table 5.3.

Table 5.3: Optimal plans for an increasing proportion of the herd calving in autumn, assuming a milk price of \$3.6/kg MS

	% of the herd calving in autumn					
	0 (Base)	**20**	**40**	**60**	**4**	**5**
% of herd calving in autumn	0	20	40	60	80	100
Stocking rate (Cows/ha)	2.46	2.46	2.44	2.41	2.39	2.35
MS/cow (kg)	430	430	430	430	430	430
MS/ha (kg)	1,060	1,060	1,049	1,036	1,028	1,010
Lactation length (days)	300	300	300	300	300	300
Pasture area conserved (% of pasture area)	2	8	10	17	23	28
Spring N fertilizer (kg N/ha)	57	55	0	0	0	0
Autumn N fertilizer (kg N/ha)	143	145	200	200	200	200
Total N fertilizer (kg N/ha)	*200*	*200*	*200*	*200*	*200*	*200*
Feed use:						
Grazing off (% of herd)	84	82	60	40	20	0
Grazed pasture (kg DM/ha)	13,204	12,888	12,260	11,481	10,684	9,744
Grazed pasture (kg DM/cow)	5,358	5,239	5,024	4,764	4,470	4,146
Home made pasture silage (Kg DM/cow)	33	158	232	384	525	662
Bought in pasture silage (Kg DM/cow)	0	41	202	332	476	619
Barley grain (Kg DM/cow)	64	39	45	57	93	155
Total supplements (kg DM/cow)	122	238	479	773	1,094	1,436
Total Gross Margin (TGM) (\$)	278,489	270,463	256,121	239,938	222,587	195,020
Reduction in TGM in relation to base plan (\$)	-	8,026	22,368	38,551	55,902	83,469
Reduction in TGM (% of base plan TGM)	-	3	8	14	20	30
Reduction in TGM (\$/kg MS)		0.04	0.13	0.22	0.32	0.49
Average variable production cost (\$/kg MS)	2.05	2.10	2.16	2.24	2.33	2.46
Winter premium (May, June & July) required to equal base plan TGM (\$/kg MS)		0.26	0.57	0.80	0.99	1.30
Milk flow at peak month (% of total production)	13.1	12.4	11.6	10.8	11.3	13.0

Table 5.3 shows that, as the proportion of the herd calving in autumn increases, the stocking rate decreases steadily. Since the model predicts that milking well fed cows is the most profitable option in all plans, the reduction in milksolids production per hectare is driven by a decreasing stocking rate, rather than milksolids production per cow. The total drop in production between the base plan and the all-autumn plan is 50 kg MS/ha, or 4.7%.

With increasing numbers of cows calving in autumn, the mismatch between the patterns of pasture demand and growth increases. Consequently, increasing amounts of pasture are conserved and transferred to the periods of lowest pasture growth rates (autumn and winter), to meet the nutritional requirements of autumn calving cows. Thus, only 2% of the pasture area is conserved in the base plan, while 28% of the area is conserved in the all-autumn calving situation (plan 5). This way, less pasture is grazed and more is conserved, thus reducing the efficiency of pasture utilisation and increasing feeding costs.

Nitrogen fertilizer is again used at the maximum allowed level (200 kg N/ha) in all plans. However, the pattern of seasonal nitrogen use changes significantly as calving dates are altered, suggesting that the model is using nitrogen as an important means of altering seasonal feed supplies. Thus, with more cows calving in autumn, N application rates in autumn increase at the expense of spring applications. When the proportion of the herd calving in autumn reaches 40%, all the nitrogen fertilizer is applied during autumn.

As calving dates are altered, the use of purchased supplements increases sharply, in particular, pasture silage. Thus, no pasture silage is bought in the base plan, whereas 619 Kg DM/cow of pasture silage are purchased in plan 5. The use of barley grain first decreases slightly, and then increases moderately to reach 155 kg DM/cow in the all-autumn situation. In total, the use of supplements (made on the farm and purchased) increases sharply from 102 kg DM/cow in the all-spring calving system to 1,436 kg DM/cow in the all-autumn calving system, an increase of more than 1300%.

On the other hand, as the proportion of cows calving in autumn increases, the number of cows grazed off farm decreases, since all the autumn calving cows are grazed on the farm during the dry period. This occurs because, with decreasing numbers of cows calving in spring, a surplus of pasture develops during late summer and early autumn. This surplus is used for grazing the autumn calving dry cows on the farm. Spring calving cows, on the other hand, are all grazed off the farm, because the pasture is used more profitably as feed for lactating autumn calving cows than for dry cows.

These results compare well with the results of a trial conducted by Garcia *et al.* (1998). This trial was conducted at Massey University's N° 1 Dairy Farm, to compare the effect of calving season on the physical and financial productivity of the systems. Thus, three systems were compared, namely, 100% spring calving, 100% autumn calving, and 50/50 split calving. The results related to the 100% autumn system are compared with model results for the same level of autumn calving in Table 5.4.

Table 5.4: Comparison of model and trial results for systems involving 100% of the cows calving in autumn

	Garcia et al (1998)	Model
Stocking rate (Cows/ha)	2.00	2.35
Pasture area conserved (% of pasture area)	31	28
Total diet composition (% of DM):		
Grazed pasture	80%	74%
Supplements	20%	26%

As can be seen in Table 5.4, calving all the cows in the autumn rather than in the spring results in high amounts of feed harvested as silage and fed to the cows. However, even in the 100% autumn systems, high proportions of total cows' dry matter intake is from grazed pasture, suggesting that high levels of pasture utilization can also be achieved with winter milk production systems. The lower contribution of pasture to the total dry matter intake in the model solution is due to the shorter winter pasture growth rates in the South Island compared with North Island conditions, where the physical trials took place.

The effect on farm gross margins of shifting calving from all August through to all April is shown in figure 5.5.

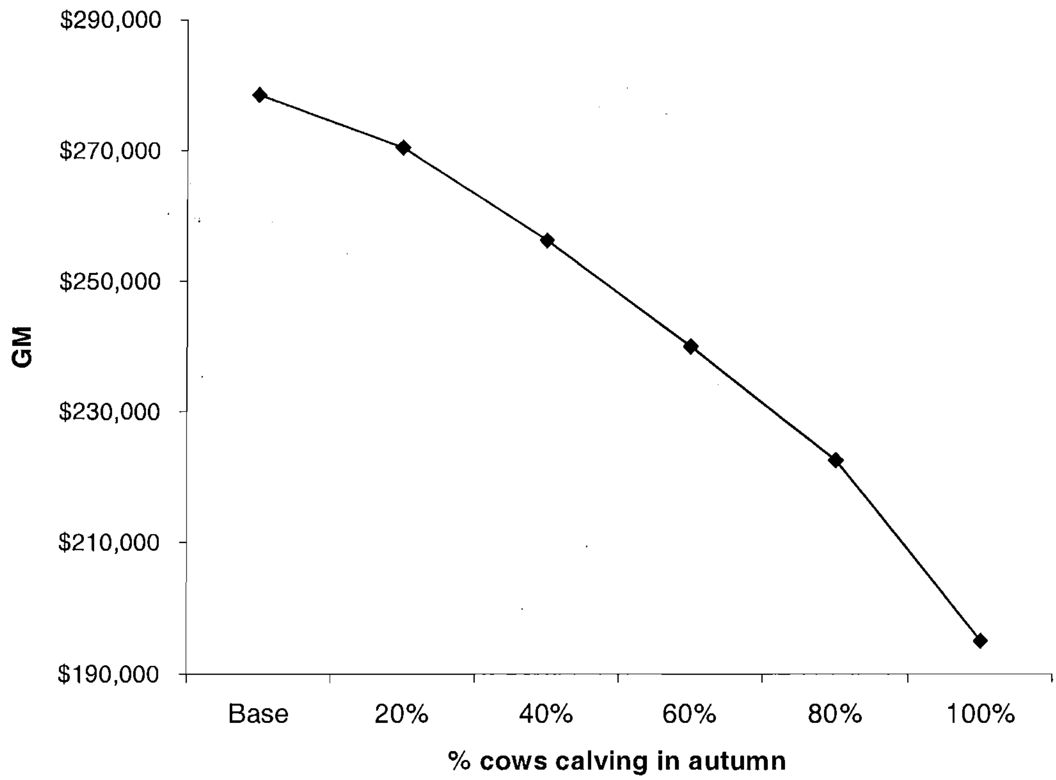


Figure 5.6: Effect on farm gross margin of calving an increasing proportion of the herd in autumn under a milksolids price of $3.6/kg MS

As shown in figure 5.5, as the proportion of cows calved in autumn increases, increasing costs cause sharp drops in profit. The reductions in the gross margins of plans 1 through to 5 with respect to the base plan represent the marginal costs of moving away from seasonal production. Figure 5.6 shows the marginal costs of plans 1 through to 5 expressed as a percentage of the base plan gross margin. It shows that, for instance, the gross margin of the all-autumn plan is 30% lower than that of the base plan.

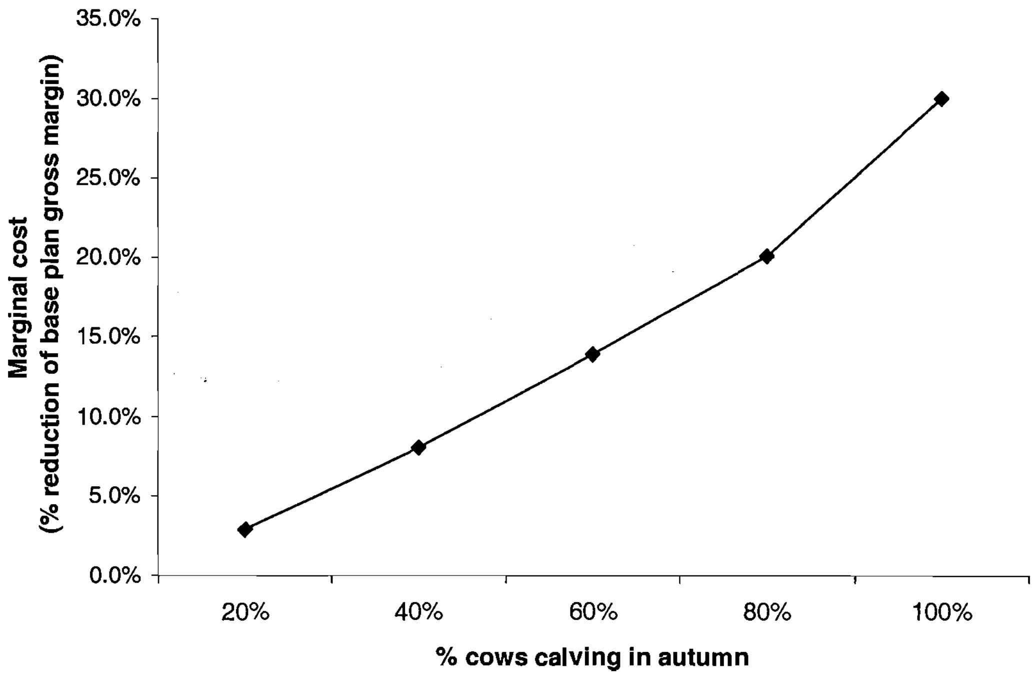


Figure 5.7: Marginal cost of plans with increasing levels of autumn calving, assuming a milksolids price of $3.6/kg MS (% of base plan GM)

The same relationship is shown in Figure 5.7, recalculated as the decrease in gross margin per kg MS over the whole season.

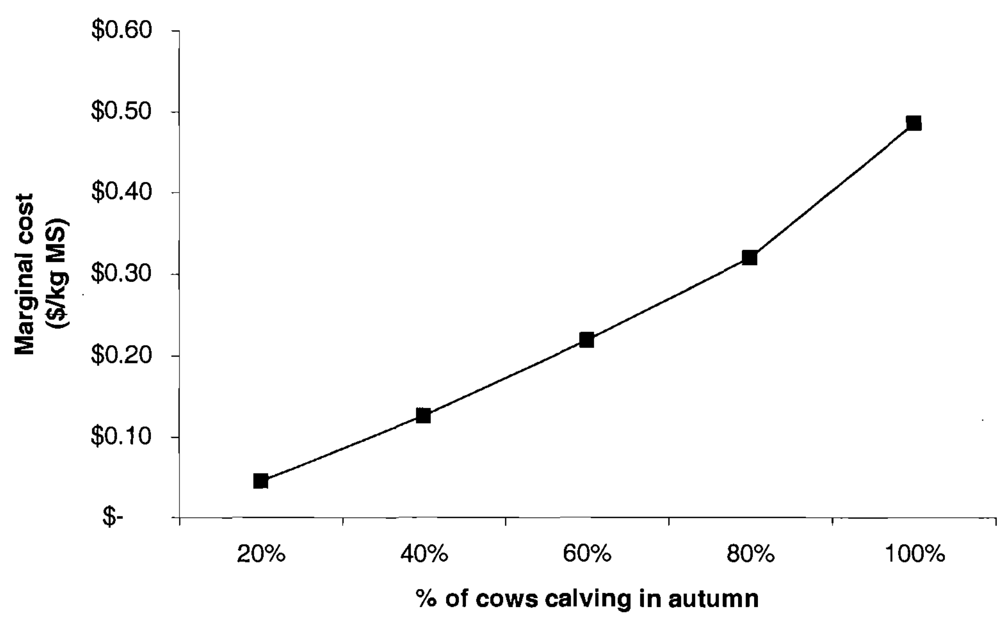


Figure 5.8: Marginal cost, expressed as $/kg MS, of plans with increasing levels of autumn calving, under a milksolids price of $3.6/kg MS.

These costs represent the premiums that would be required per kg milksolids over the whole season to make systems involving varying levels of split calving as profitable as the seasonal system. For instance, a farmer calving 100% of the herd in autumn would need to receive a price incentive of around 49¢/ kg MS over the whole of the lactation for economic comparability with a farmer calving 100% of the herd in spring, assuming both farms have similar resources. An alternative approach would be to allocate the premiums to the milk supplied during the most difficult winter months, namely, May, June, and July (see Table 5.3). Thus, applying this approach to the situation presented above, the total autumn calver would need to receive a premium of $1.30 /kg MS for the milk supplied during May, June, and July.

Production costs increase due to greater use of supplements and extra costs associated with milking the cows during winter. These costs have been included in the objective function coefficients of the autumn calving cows, and include: increased labour, electricity and shed expenses (See Appendix C for full details).

A 3-year trial set up at the Northland Agricultural Research Farm to compare the management systems and profitability of 100% autumn calving versus spring calving determined that total autumn calvers needed a 90¢ winter premium to break even at payout of $3.50 (Chestnut, 2003). This premium is 40¢ lower than that calculated in the present study, under a similar payout. This difference is probably due to the North Island being more suitable for split calving systems than the South Island, due to the differences in pasture growth patterns. Thus, in many parts of the North Island pasture growth is slower in summer than in winter, making autumn calving a better alternative (Penno and Kolver, 2000; Holmes, 2001). In fact, the occurrence of a series of hot, dry summers in Northland, coupled with warm temperatures and moderate pasture growth in winter, encouraged many farmers to adopt autumn calving or split calving systems in the past 10 years (Hodgson, 1999). Further, in the South Island there is an extra need for supplementation compared with the North Island because pasture growth is restricted to a shorter period (Macdonald, 1999).

Regarding the seasonality of milk production, the system involving 60% of the herd calving in autumn (plan 3) shows the smoother supply pattern (i.e. the supply curve with the lowest peak milk flow). The effect of this level of split calving on the seasonal milk flow is shown in Figure 5.8.

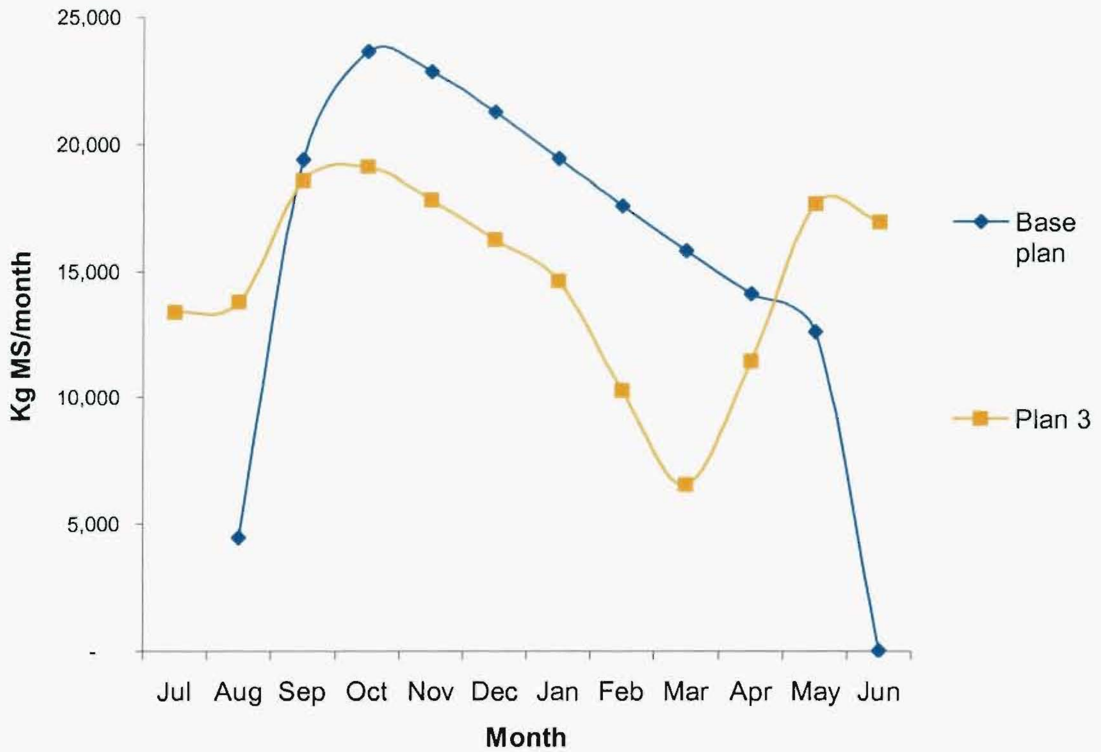


Figure 5.9: Milk supply curves of the base plan and plan 3

As shown in figure 5.8, calving 60% of the cows in autumn would have the effect of reducing the peak by about 20%. The minimum flow of this curve would be around 34% of the peak. From Table 5.3, it is clear that the price differential required to offset the marginal costs associated with a supply pattern such as that of plan 3 would be 22¢ /kg MS over the total milk supply, or 80 ¢ /kg MS over the milk supplied during winter (May, June, and July).

5.3.2 Plans under a Milksolids Price of $4.2/kg MS

These plans are summarised in Table 5.5.

Table 5.5: Optimal plans for an increasing proportion of the herd calving in autumn, assuming a milk price of $4.2/kg MS

Organisation of optimal plans	% of the herd calving in autumn					
	0 (Base)	20	40	60	80	100
Stocking rate (Cows/ha)	2.62	2.68	2.74	2.82	3.02	3.30
MS/cow (kg)	430	430	430	430	430	430
MS/ha (kg)	1,127	1,152	1,179	1,214	1,297	1,418
Lactation length (days)	300	300	300	300	300	300
Pasture area conserved (% of pasture area)	0	0	0	0	0	0
Spring N fertilizer (kg N/ha)	57	45	20	0	0	0
Autumn N fertilizer (kg N/ha)	143	155	180	200	200	200
Total N fertilizer (kg N/ha)	*200*	*200*	*200*	*200*	*200*	*200*
Feed use:						
Grazing off (% of herd)	100	100	87	66	51	33
Grazed pasture (kg DM/ha)	13,654	13,698	13,412	12,977	12,569	11,987
Grazed pasture (kg DM/cow)	5,209	5,112	4,893	4,596	4,167	3,636
Home made pasture silage (Kg DM/cow)	0	0	0	0	0	0
Bought in pasture silage (Kg DM/cow)	139	267	514	823	1,246	1,717
Barley grain (Kg DM/cow)	97	77	63	67	91	158
Total supplements (kg DM/cow)	236	344	578	890	1,337	1,875
Total Gross Margin (TGM) ($)	389,872	386,078	375,668	361,811	342,289	313,140
Reduction in TGM in relation to base plan ($)	-	3,794	14,204	28,061	47,583	76,732
Reduction in TGM (% of base plan TGM)	-	1.00	3.6	7.2	12.2	19.7
Reduction in TGM ($/kg MS)		0.02	0.07	0.14	0.23	0.35
Average variable production cost ($/kg MS)	2.17	2.23	2.33	2.45	2.65	2.90
Winter premium (May, June & July) required to equal base plan TGM ($/kg MS)		0.14	0.39	0.57	0.72	0.85
Milk flow at peak month (% of total production)	13.0	12.4	11.8	11.3	10.9	13.0

The first obvious feature of this sequence of plans, in contrast to the plans discussed previously, is the increase in stocking rates as the proportion of the herd calving in autumn increases. This again drives the increase in MS production per hectare, as milksolids production per cow remains the same in all plans. The total rise in production between the base plan and the all-autumn plan is 291 kg MS/ha, or around 26%.

It is interesting that the stocking rate increases despite a worsening mismatch between pasture supply and demand. The reason seems to be that with fewer cows calving in spring, a surplus of pasture develops in spring and summer. Thus, the model is increasing the stocking rate to maximize pasture utilization via direct grazing, because under a price of $4.2/kg MS the opportunity cost of making pasture silage becomes too high. Consequently, it becomes more profitable to fill the feed deficit occurring in autumn and winter by purchasing supplements, rather than by transferring pasture via conservation. This explains the absence of pasture conservation in all plans, and the sharp increase in the use of purchased supplements as calving dates are altered. Purchased pasture silage is again the supplement of choice. Thus, 139 kg DM/cow of pasture silage are bought in the base plan, whereas 1,717 Kg DM/cow of pasture silage are purchased in plan 5. The use of barley grain shows a moderate increase, from 97 kg DM/cow in the base plan to 158 kg DM/cow in the all-autumn calving plan.

Nitrogen fertilizer is again used strategically to provide more pasture in autumn, at the maximum allowed level (200 kg N/ha). Finally, as the proportion of cows calving in autumn increases, the number of cows grazed off the farm decreases, but at a slower rate than in the previous plans. It will be recalled that in the previous plans all the autumn calving cows were grazed on the farm, grazing off being used only for spring calvers. In these plans, however, the spring calving cows, as well as some of the autumn calving cows, are grazed off the farm. This occurs due to two reasons: (i) under a milksolids price of $4.2/kg MS, the opportunity cost of grazing dry cows on the farm is higher than under a lower milksolids price, and (ii) increasing stocking rates mean that there is less surplus pasture in late summer and early autumn available for grazing on the autumn calving cows.

As would be expected, the costs associated with moving away from seasonal production cause the gross margin of subsequent plans to decline sharply. Figure 5.9 shows the marginal costs of plans 1 through to 5 expressed as a percentage of the base plan gross margin.

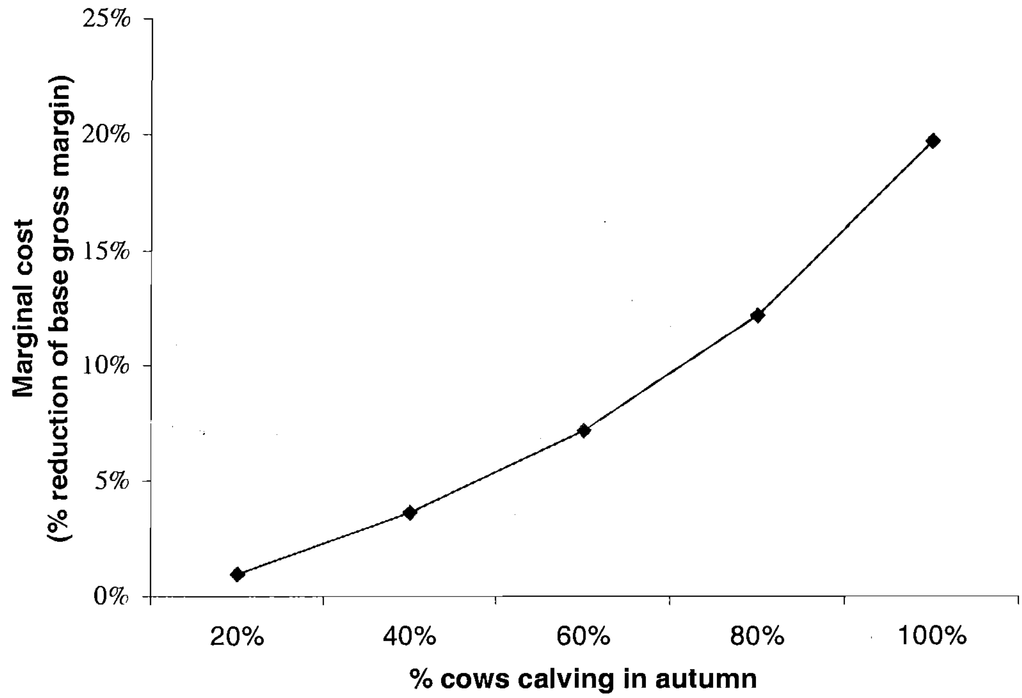


Figure 5.10: Marginal cost of plans with increasing levels of autumn calving under a milksolids price of $4.2/kg MS (% of base plan GM)

Figure 5.9 shows that, for instance, the gross margin of the all-autumn plan is around 20% lower than that of the base plan. It will be recalled that, under a price of $3.6/kg MS, a plan with this level of autumn calving had a gross margin 30% lower than the base plan gross margin (Figure 5.6). This suggests that, as the base milksolids price increases, the marginal cost of moving away from seasonal production decreases, provided all the costs considered in the analysis remain unchanged. Hence, under a milksolids price of $4.2/kg, a farmer calving 100% of his herd in autumn would need to receive a price incentive of around 35¢/ kg MS over the whole of the lactation for economic comparability with a farmer calving 100% of the herd in spring. Under a milksolids price of $3.6, however, the differential required would be 49¢/ kg MS (see Table 5.3). This issue is further discussed in the next section.

5.3.3 Effect of the Base Milksolids Price on the Costs of Changing the Seasonality of Milk Production

From the previous discussion, it was apparent that the base milksolids price has an important effect on the costs of changing milk supply patterns, and hence, on the price incentives that would be required to compensate for such costs. Figures 5.10 and 5.11 illustrate this conclusion. Figure 5.10 shows the marginal costs of plans with varying proportions of the herd calving in autumn, expressed as a percentage of the base plan gross margin, under different milksolids prices.

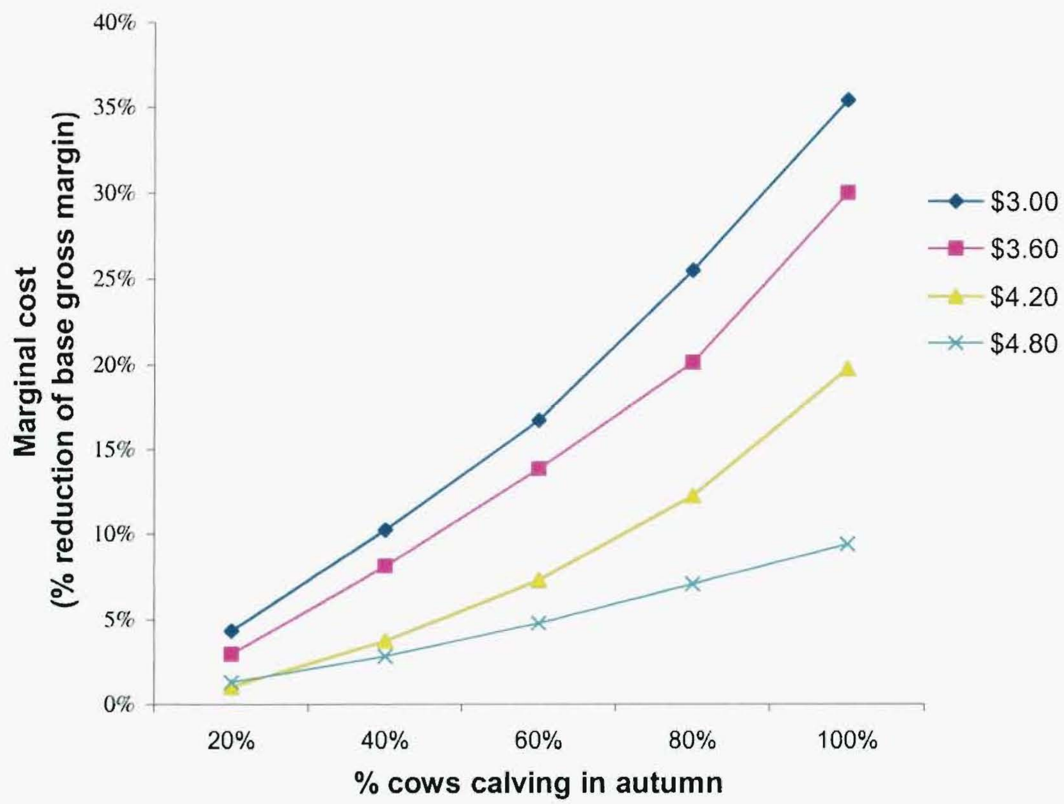


Figure 5.11: Effect of the base milksolids price on the marginal cost of changing milk supply patterns

As can be seen from Figure 5.10, with higher milksolids prices the gross margin becomes much less sensitive to changes in calving dates. This is because, as the milksolids price increases, the optimal systems become more intensive, with heavy use of purchased supplements. In such systems supplements make up a much greater proportion of the cows diet (see Figure 5.2) and, therefore, there is much less reliance on the seasonal pasture growth. This analysis assumes, of course, that per unit input costs, in particular feed costs, remain unchanged. In fact, the key factor driving the variations in gross margin shown in Figure 5.10

is not the milksolids price on its own, but the relationship between this price and input costs, particularly supplements. This finding supports the assertion made by Penno and Kolver (2000), that when milk price is strong enough and supplementary feed costs are low enough, calving date and seasonality of production becomes far less important than in pasture-only systems. Kolver (2001) predicts that the evolution of non-seasonal dairying systems in the near future will be a natural progression following intensification, and may occur irrespective of seasonal price incentives.

This implies that as the milksolids price increases relative to feed input costs, the premiums required to compensate farmers for supplying out of season milk decrease. This is clearly shown in Figure 5.11.

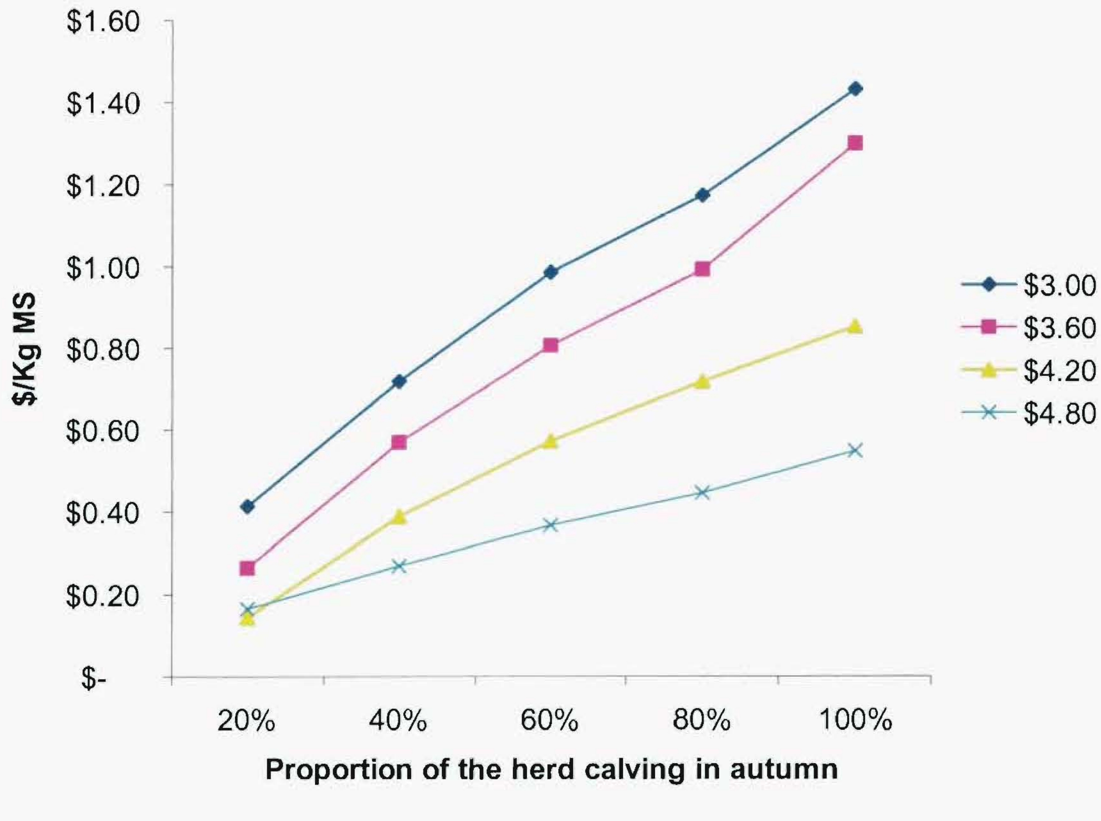


Figure 5.12: Winter premiums that would be required to give equal profits for all systems under varying milksolids prices

5.3.4 Restriction on Pasture Silage Use

In Chapter 2, the availability of high quality, low cost supplements in the South Island was highlighted. Supplements such as whole crop cereal silage and barley grain are already playing an important role in the dairy industry as it expands and intensifies (Hogg et al, 2002). Thus, these could be used to produce out of season milk profitably. However, the optimal plans discussed so far included only small amounts of barley grain, whereas whole crop cereal silage was not included in any of the solutions. In contrast, great amounts of pasture silage were included in many plans, in particular those involving high proportions of autumn calving. These results seem sensible, as pasture silage is the cheapest source, after pasture, of metabolisable energy (see Appendix B). It also contains high levels of crude protein (16%), and therefore can make up a high proportion of the diet of high yielding cows without protein intake becoming limiting. This may explain the fact that crude protein constraints were non-binding in all solutions, even in the ones where supplements made up very high proportions of the cows diet.

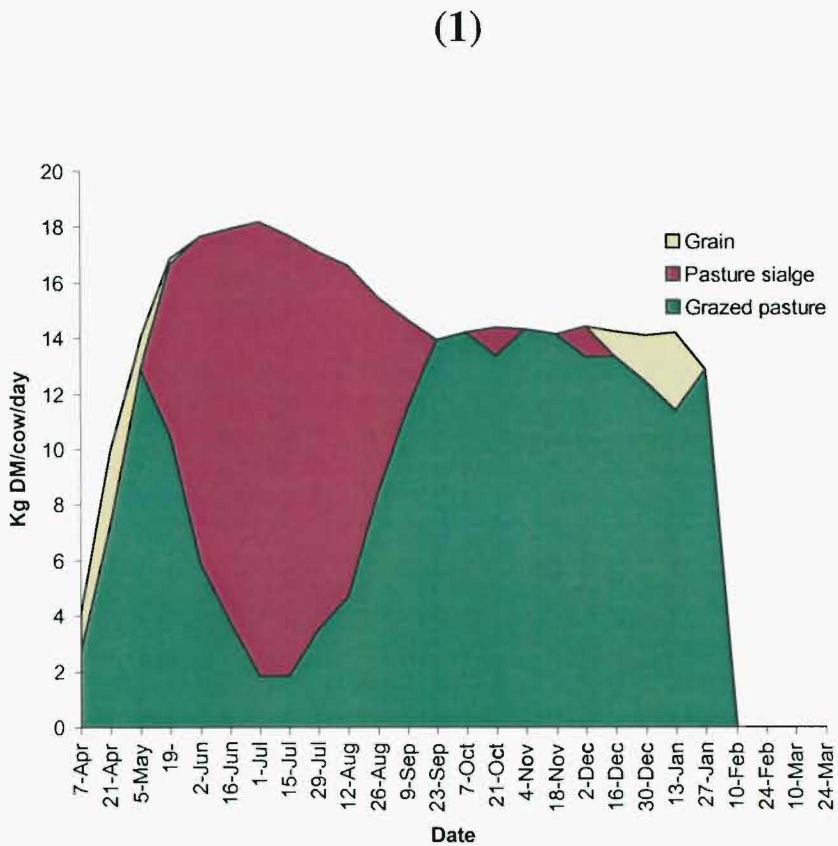
However, the marginal cost of inclusion ($Z_j - C_j$) values on whole crop cereal silage were very small in most solutions, and took values of 0 in some of them. This suggests that this supplement could also be used profitably. On the other hand, given the lower crude protein content of these supplements (barley grain = 10% CP; whole crop cereal silage = 12% CP) protein intake may become limiting in diets containing high proportions of such supplements.

To investigate if whole crop cereal silage and barley grain could be used instead of pasture silage profitably, and to explore the nutritional feasibility of using significant amounts of these supplements in the diet of lactating cows, model runs were made constraining the amount of pasture silage used. A constraint forcing 100% of the cows to calve in the autumn was also added, to represent a situation where a high proportion of the cows diet would be made up of supplements. The runs were made under a milksolids price of $4.2/kg MS. Pasture silage was reduced gradually until protein became limiting. The plan where this occurred was compared with a plan with the same level of autumn calving, and under the same milksolids price ($4.2) in which the amount of pasture silage was unconstrained (Plan 5, Table 5.5). These plans are presented in Table 5.6.

Table 5.6: Optimal plans involving 100% of the herd calving in autumn, with different amounts of pasture silage used, and assuming a milksolids price of $4.2/kg MS

Organisation of optimal plans	**Plans**	
	Unconstrained pasture silage use	**Constrained pasture silage use**
% of herd calving in autumn	100	100
Stocking rate (Cows/ha)	3.30	3.30
MS/cow (kg)	430	430
MS/ha (kg)	1,418	1,418
Pasture area conserved (% of pasture area)	0	0
N fertilizer (kg N/ha)	200	200
Feed use:		
Grazing off (% of herd)	33	33
Grazed pasture (kg DM/ha)	11,987	11,987
Grazed pasture (kg DM/cow)	3,636	3,636
Home made pasture silage (Kg DM/cow)	0	0
Bought in pasture silage (Kg DM/cow)	1,717	856
Barley grain (Kg DM/cow)	158	158
Whole crop cereal silage (kg DM/cow)	0	950
Total supplements (kg DM/cow)	1,875	1,964
Total Gross Margin ($)	313,140	312,630

As shown in Table 5.6, the plan where crude protein intake becomes limiting (plan 2) includes only 50% of the amount of pasture silage used in the unconstrained solution (plan 1). Thus, plan 1 includes 1,717 kg MS of pasture silage fed per cow, whereas plan 2 includes only 856 kg DM/cow, a difference of 861 kg. This amount of pasture silage is substituted by 950 kg DM of whole crop cereal silage per cow in plan 2. However, this change has only a marginal effect upon the optimal solution, since both plans are almost identical. Plan 2 shows a slightly lower gross margin than plan 1, because more whole crop cereal silage needs to be purchased to support the same number of cows, due to the lower ME content of this supplement. Therefore, the model substituted whole crop cereal silage for pasture silage with no significant impact upon the profitability of the system. The feeding patterns of both plans are shown in Figure 5.12.



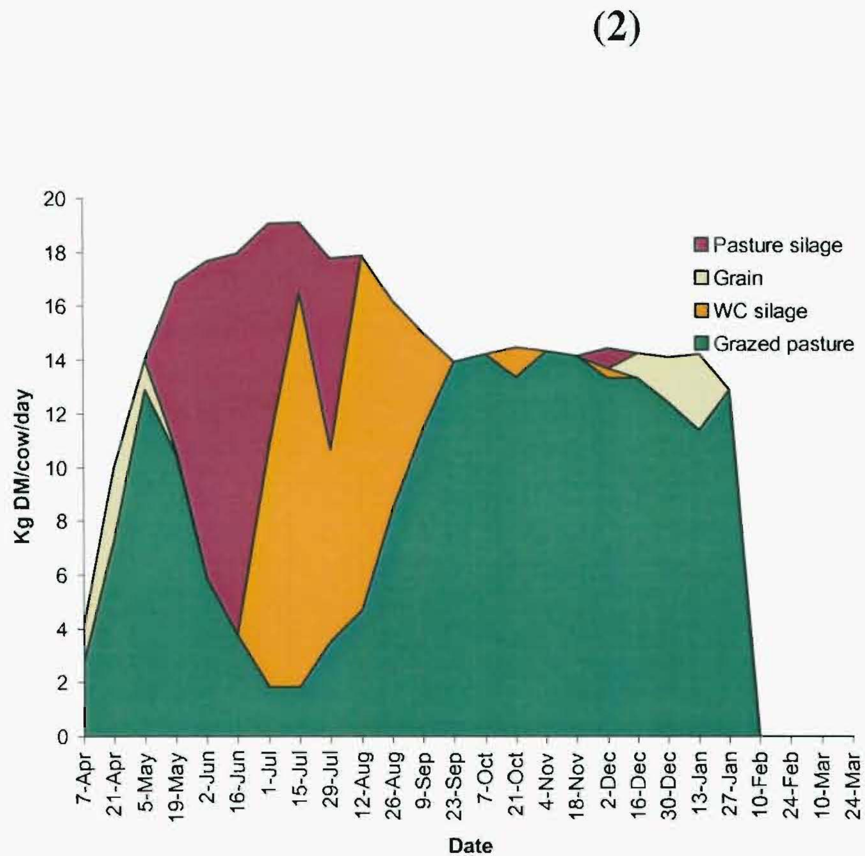


Figure 5.13: Diet composition of cows in the plans with unconstrained (1) and constrained (2) pasture silage use

In both plans, substantial amounts of supplements need to be fed during winter, because autumn calving cows are unable to meet their high nutritional requirements of early lactation solely with grazed pasture, due to the very low pasture growth rates at this time of the year.

This result suggests that whole crop cereal silage can make up important proportions of the cows diet during periods of feed deficit, since protein intake only becomes limiting when more than 75% of the cows diet is made up of this supplement. This occurred in period 1 (July 15 to July 31), during which almost 14 kg DM of whole crop cereal silage was fed daily to the cows. However, no published experimental results were found on the use of whole crop cereal silage in dairy cow feeding that would justify the use of such large amounts of this supplement. Therefore, this result must be considered with caution.

5.3.5 Discussion of Out-of-Season Production Systems

In this study, the extra costs of achieving smoother supply patterns were calculated. These costs were mainly related to increased feeding and labour costs. However, interpretation of these results calls for consideration of other factors associated with split and all-autumn calving systems, which were not incorporated into the model.

Split calving operations are complicated systems compared to seasonal supply. They require careful management of feeding and assessment of weather issues. Many of the problems and constraints of autumn and winter milk production are difficult or impossible to quantify in monetary terms, and that the costs of the marginal changes involved are not easy to predict.

A favourable feature of split calving may be the opportunity to run separate herds as leaders and followers to achieve better spring pasture control. On the other hand, during very wet winter conditions, in particular on farms with heavy soils and poor drainage, winter grazing could cause severe treading damage to the soils. Even what appears to be moderate damage may have an effect on pasture regrowth that extends well into the spring period (Ridler, 1986). To overcome this problem, dairy farmers use a wide variety of facilities, surfaces, and management systems for keeping cows off pasture during winter (Stewart *et al.*, 2002). Some use farm races, cow yards, sacrifice paddocks, and specially constructed pads, like the one assumed in this model. Whereas a feed pad may reduce soil and pasture damage, foot problems and race deterioration may increase as a result of more time spent off paddocks (Jones et al, 1997).

While split calving does even out the workload, there is an eight-month period of calving/mating/calving/mating, supplementary feeding, and two seasons of calf rearing. Further, with split calving there is an overlap of calving and drying off in the autumn, and a year-round milking tie. While the additional labour costs associated with out of season production were accounted for in this study (see Appendix C for details), other labour-related issues also need to be considered. Hence, farmers running split calving systems may find it difficult to attract qualified staff, as staff would probably choose a seasonal calving farm over a split calving farm everything else being equal. To overcome this problem, farmers may need to give staff more time off, which will result in lower productivity. Staff motivation could also be improved by giving them a greater variety of work.

Transitional costs are also an important consideration. These costs, which were not considered in this study, are likely to be high as it will take at least two seasons to fully change over from spring to autumn calving.

The relative importance of the factors and costs discussed above will depend on the particular situation. Thus, for some farmers it might be technically infeasible, or extremely costly, to implement out of season production systems due to difficult climatic and physical conditions. For some farmers, on the other hand, it might be easier to produce winter milk. Hence, these farmers might not need to either build expensive feeding pads, or use extra labour to produce winter milk efficiently.

In considering the aggregate implications of these results, smoother milk flows to the factories could be achieved by adopting split calving systems, such as those represented by the plans previously discussed. However, an even supply pattern overall could also result if some farmers remained exclusively spring calving, while others specialized in winter milk production. The unsuitability of some farms for winter milk production means that that the latter would be a more realistic scenario. To illustrate this point, reference to Figure 5.8 will be made. The supply curve shown in Figure 5.8 corresponds to a split calving system where 60% of the herd calves in autumn and the rest in spring. The aggregate milk flow pattern will show a similar shape to this supply curve if all farmers adopt this level of split calving. However, the same aggregate milk supply pattern could also be achieved if 40% of the farmers remain with spring calving, while 60% of the farmers adopt a 100% autumn calving system. Even smoother aggregate supply curves could result from a combination of spring calving systems and varying levels of split calving systems.

5.4 Estimation of Farmers' Responses to Seasonal Pricing Schemes

The previous section dealt with the estimation of the effects of seasonal shifts in calving patterns on variable production costs, and the price differentials that would be required to compensate farmers who move away from seasonal production. This analysis had assumed the uniform pricing system currently used in New Zealand, that is, the same price for every month of the year. This section describes the third phase of the experimentation carried out with the model in which the model was used to simulate seasonal pricing systems that could be implemented in New Zealand. This was achieved by replacing the milksolids prices in the objective function with alternative price series. The aim was to predict dairy farmers' responses to alternative differential pricing systems, and to estimate the premiums that would be required to encourage farmers to change their milk supply patterns, as well as the extra production costs associated with such responses.

Three types of seasonal pricing schemes were considered, namely:

(i) Schemes involving winter premiums for the milk supplied during May, June, and July.

(ii) Schemes involving shoulder premiums for the milk supplied during February, March, and April.

(iii) Complex schemes involving both shoulder and winter premiums.

These schemes are illustrated in Figure 5.13. The runs were made under two base milksolids price scenarios, namely, \$3.6 and \$4.2 /kg MS. This was done with the aim of exploring the effect of the base milksolids price on the premiums required to encourage out of season production. Under each scheme, the premiums were increased and the model ran iteratively.

The objective of a seasonal price structure is to encourage a relatively uniform pattern of milk production by paying higher prices for the milk supplied in difficult months, such as during winter. This helps to ensure a more even pattern of factory capacity utilisation and reduces the total industry capacity requirements in the peak production period. Therefore, the supply patterns resulting from the experiments are evaluated in terms of the reduction of the peak in relation to total production.

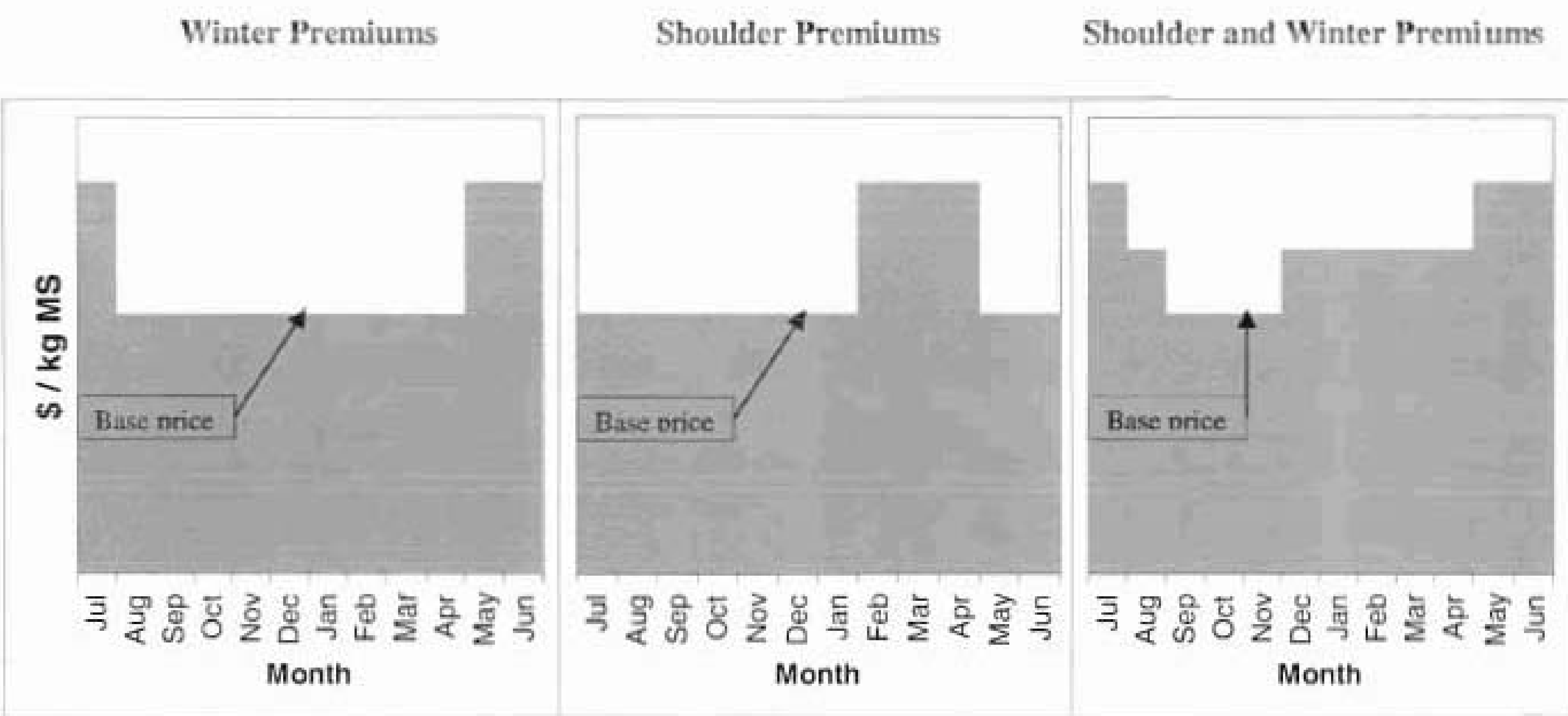


Figure 5.14: Seasonal pricing schemes considered in this study

5.4.1 Schemes Involving Winter Premiums

The plans obtained for increasing levels of winter premiums under both milksolids prices considered are summarised in Table 5.7. Full details of the plans generated are included in Appendix D.

The first obvious feature of the sequence of plans is the change in calving dates as the winter premiums are increased. Two trends are evident. Under \$3.6/kg MS, increasing premiums produce optimal solutions with increasing proportions of the herd calving in autumn. The shift towards split calving is triggered by a premium of 60¢/kg MS, with about 9% of the cows calving in autumn and the rest in spring. With a premium of \$1.2/kg MS, 85% of the herd is calved in autumn. Under \$4.2/kg MS, the calving patterns are more complex, and the premiums required to trigger the changes are lower than under \$3.6/kg MS. Thus, a premium as low as 20¢/kg MS is sufficient to initiate the move towards split calving, with most of the cows calving in spring and autumn, and a small proportion of the herd calving in summer. With increasing premiums, the proportion of cows calving in summer and autumn increases, while the proportion of the herd calving in spring decreases. With a premium of \$1/kg MS, 86% of the cows calve in autumn, while 14 % calve in summer.

These calving patterns, involving increasing proportions of the herd calving in autumn, cause an increasing mismatch between the patterns of feed demand and pasture growth. The feed deficit is exacerbated by increasing stocking rates, driven by the increase in the average milksolids price. Consequently, the level of supplement fed per cow increases sharply. This explains the sharp increases in milksolids production costs.

These plans represent dairy farmers' responses to winter premiums. They suggest that rational farmers would respond to winter premiums by maximising the amount of milk supplied during winter, as long as the extra returns due to the bonus payments outweigh the extra costs involved in the changed system. As the gross margins of the subsequent plans increase steadily, it is obvious that the bonus payments more than compensate for the increased production costs. The milk supply patterns of the plans under both base milksolids prices are similar. Figure 5.14 illustrates the supply curves of the plans under \$3.6/kg MS. The graph showing the supply curves corresponding to plans under \$4.2 is included in Appendix D.

Table 5.7: Optimal plans for varying levels of winter premiums, under two base milksolids prices

	Premiums paid in May, June, and July ($/kg MS)											
	Base price = $3.6/kg MS						Base Price = $4.2/kg MS					
	0.00	0.40	0.60	0.80	1.00	1.20	0.00	0.20	0.40	0.60	0.80	1.00
Stocking rate (Cows/ha)	2.46	2.51	2.56	2.68	2.80	2.99	2.62	2.67	3.06	3.54	4.00	4.00
Cows calving in the month of (% of total)												
July	-	-	-	-	-	-	-	-	-	-	-	-
August	67	65	51	31	-	-	67	42	-	-	-	-
September	33	20	28	33	14	-	33	36	39	-	-	-
October	-	15	-	-	23	15	-	-	-	3	-	-
November	-	-	11	-	-	-	-	2	3	8	-	-
December	-	-	-	-	-	-	-	1	9	15	19	14
January	-	-	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	10	-	-	10	16	18	21
March	-	-	-	14	11	16	-	4	6	11	14	10
April	-	-	9	22	23	25	-	10	16	17	23	26
May	-	-	-	-	28	34	-	4	18	30	25	29
June	-	-	-	-	-	-	-	-	-	-	-	-
Total supplements (kg DM/cow)	102	169	211	540	1,006	1,353	236	357	1,051	1,705	2,127	2,176
Total Gross Margin ($)	278,489	292,027	297,018	303,160	313,891	327,195	389,870	398,440	404,770	417,630	434,100	454,770
Average variable production cost ($/kg MS)	2.05	2.06	2.11	2.23	2.37	2.52	2.17	2.20	2.50	2.79	3.00	3.00
Average milksolids price ($/kg MS)	3.60	3.65	3.69	3.78	3.90	4.02	4.20	4.23	4.31	4.40	4.48	4.56
Milk flow at peak month (% of total production)	13.1	12.5	12.1	11.4	10.8	11.9	13.0	11.9	10.2	11.7	12.1	12.2
Peak month	Oct	Nov	Nov	Oct	May	Jun	Oct	Oct	May	May	May	May

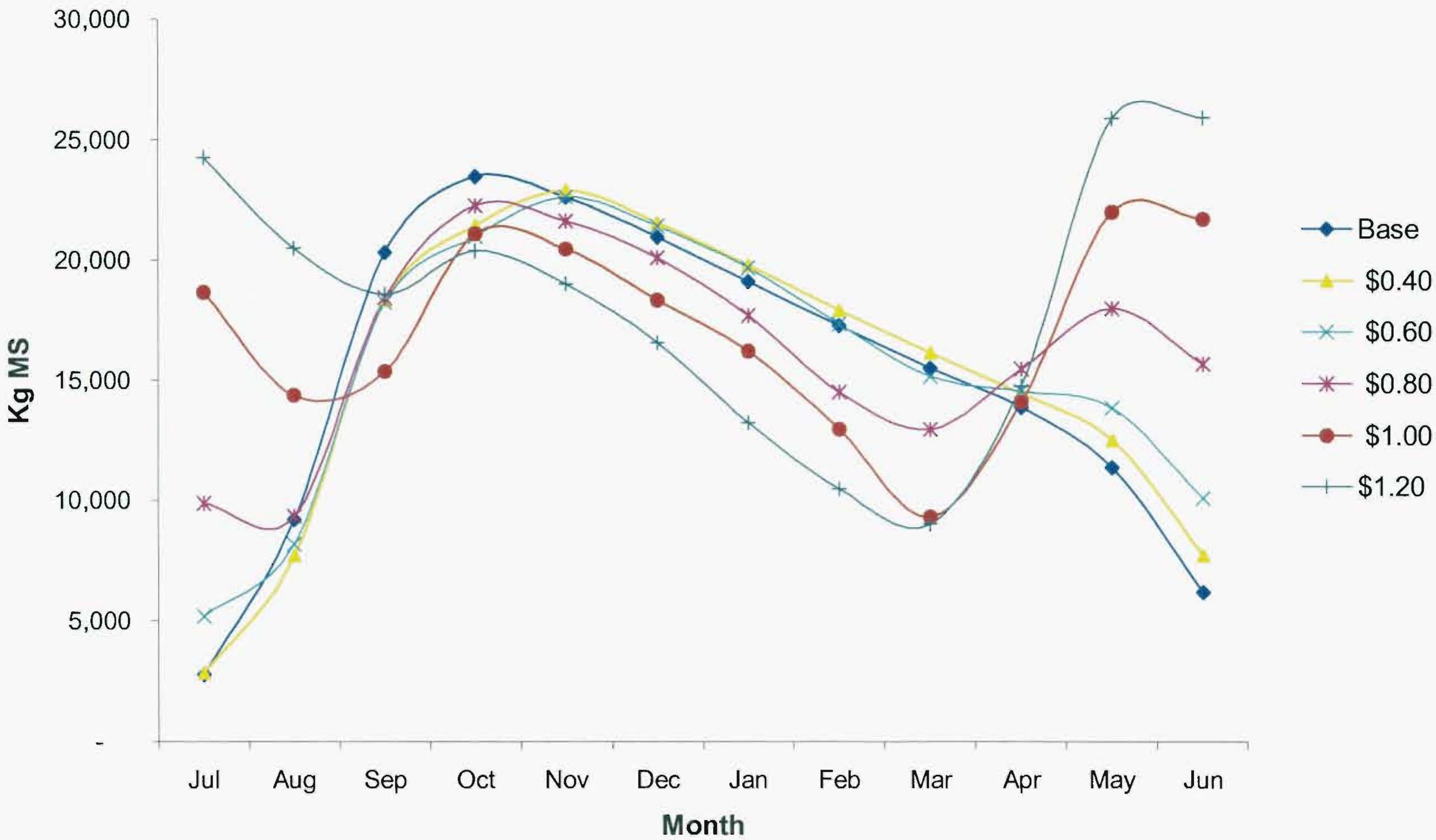


Figure 5.15: Milk supply patterns resulting from varying levels of winter premiums, under a base payout of $3.6/kg MS

As the winter premiums increase, the peaks gradually decrease in relation to total production, thus producing smoother supply curves. The month in which the peak occurs also changes with increasing levels of premiums. Under \$3.6/kg MS, the curve with the lowest peak is achieved with a premium of \$1/kg MS. The peak month of this curve accounts for 10.8% of total production, as opposed to 13.1% in the curve of the base plan. The peak has shifted from October to May. Under \$4.2/kg MS, a greater reduction in the peak is achieved with a much lower premium. Thus, the curve with the lowest peak corresponds to a premium of only 40¢/kg MS. The peak of this curve accounts for 10.2% of total production, as opposed to 13% in the base situation. The peak has again shifted from October to May. Figures 5.15 and 5.16 show the supply curves with the lowest peaks under both milksolids prices, compared with the curves of the base situations.

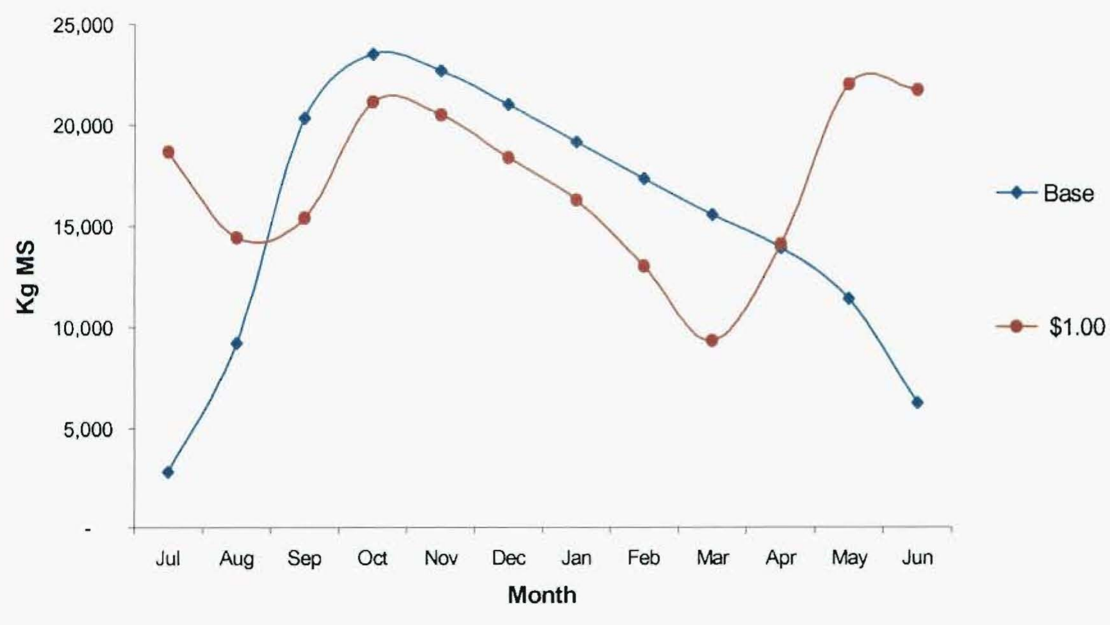


Figure 5.16: Milk supply curves of the base plan and the plan with the lowest peak, under a base milksolids price of \$3.6/ kg MS

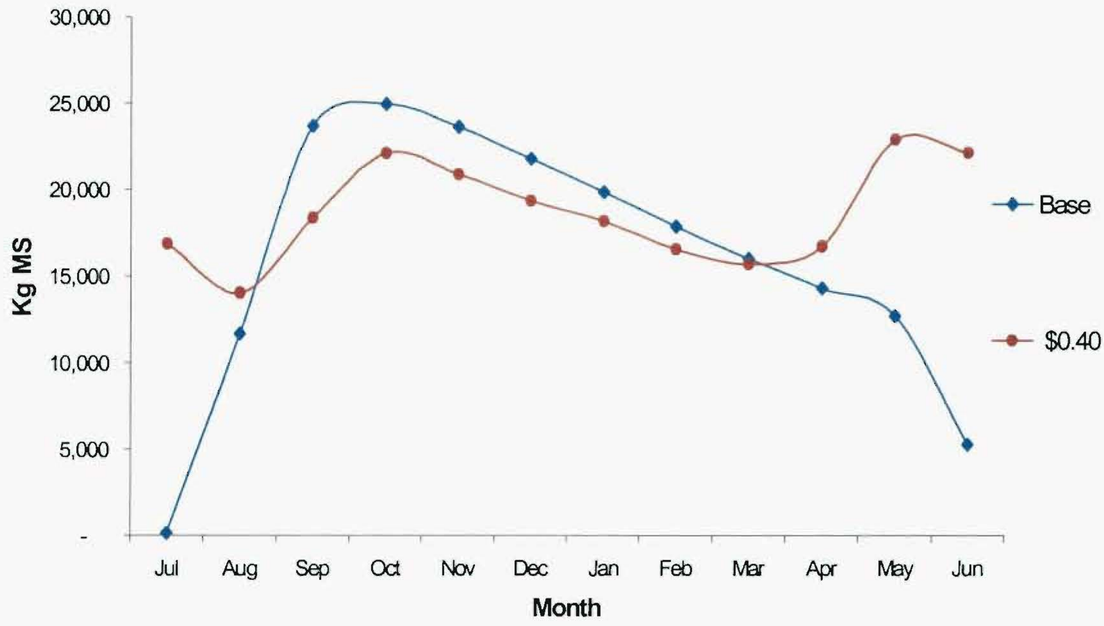


Figure 5.17: Milk supply curves of the base plan and the plan with the lowest peak, under a base milksolids price of $4.2/ kg MS

Reference to Table 5.6 will show that under $3.6/kg MS, a 2.3% reduction in the peak milk flow is associated with a 8% increase in the average milksolids price, whereas under $4.2/kg MS, a 2.8% reduction in the peak is associated with an increase in the average milksolids price of only 2.5%.

These results support the conclusion arrived at in section 5.3, that the base milksolids price has an important effect on the costs of changing milk supply patterns, and hence, on the price incentives required to encourage out of season production. Thus, as the base milksolids price increases, lower premiums are required to encourage farmers to change their milk supply patterns. These results also support the results of Blackwell (2001), who used systems simulation to predict farm management responses to different pricing structures. He concluded that the base level milksolids payout was a far more significant factor than the level of premiums. However, it is important to emphasise that the important factor here is not the base milksolids price on its own, but the price of supplements relative to the milksolids price.

5.4.2 Schemes Involving Shoulder Premiums

The plans obtained for increasing levels of shoulder premiums under both base milksolids prices are summarised in Table 5.8. Full details of the plans generated are included in Appendix D.

The important feature of these plans is the lack of significant farm management changes as the levels of shoulder premiums increase. Under \$3.6/kg MS, the plans remain almost unaltered. The only change involves adopting more spread calving patterns, by reducing the number of cows calving in spring and calving a small proportion of the herd in early summer. This has the effect of shifting the peak a month later, from October to November. Stocking rate increases only slightly. The marginal changes in both calving dates and stocking rates mean that supplement fed per cow changes little. Consequently, average variable production costs remain almost unaltered. On the other hand, the average milksolids price increases considerably with increasing levels of premiums. Under \$4.2/kg MS, a similar pattern is evident. However, at the higher premiums, the plans involve later calving dates, with the cows calving in late spring and early summer. This has the effect of shifting the peak by four months, from October to February. Stocking rate increases sharply as the levels of premiums increase. This drives the increased use of supplements, which in turns causes production costs to rise sharply. The average milksolids prices also increases markedly with rising levels of premiums.

Under both milksolids prices considered, the peak milk flow decreases marginally as the levels of shoulder premiums increase. The milk supply patterns of the plans under both base milksolids prices are similar. Figure 5.17 illustrates the supply curves of the plans under \$3.6/kg MS. The graph showing the supply curves of plans under \$4.2 is included in Appendix D. These results imply that price incentive schemes involving shoulder premiums would increase the amount of milk supplied after the peak period. However, they would not be a cost effective means of reducing the seasonality of milk production, as sharp increases in the average milksolids price would bring about only marginal reductions in peak milk flows. Shoulder premiums would not be effective in encouraging dairy farmers to change their farming systems significantly, because farmers would be able to take advantage of the premiums even if they do not respond, given that they are already supplying important amounts of milk during February, March, and April.

Table 5.8: Optimal plans for varying levels of shoulder premiums, under two base milksolids prices.

	Premiums paid in February, March, and April ($/kg MS)											
	Base price = $3.6/kg MS						Base Price = $4.2/kg MS					
	0.00	**0.40**	**0.60**	**0.80**	**1.00**	**1.20**	**0.00**	**0.20**	**0.40**	**0.60**	**0.80**	**1.00**
Stocking rate (Cows/ha)	2.46	2.50	2.51	2.50	2.49	2.54	2.62	2.65	2.70	2.82	4.00	4.00
Cows calving in the month of (% of total)												
July	-	-	-	-	-	-	-	-	-	-	-	-
August	67	65	72	65	62	59	67	62	55	43	-	-
September	33	30	12	17	18	22	33	33	31	26	31	26
October	-	6	9	9	8	3	-	5	6	-	-	-
November	-	-	7	7	8	11	-	-	8	18	17	25
December	-	-	-	3	5	5	-	-	1	4	15	12
January	-	-	-	-	-	-	-	-	-	10	37	37
February	-	-	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-	-	-
Total supplements (kg DM/cow)	122	130	135	135	150	153	236	288	305	645	2,179	2,184
Total Gross Margin ($)	278,489	302,305	311,979	321,797	331,750	341,449	389,870	403,550	413,365	422,830	430,890	450,570
Average variable production cost ($/kg MS)	2.05	2.05	2.06	2.06	2.06	2.07	2.17	2.18	2.20	2.32	3.00	3.00
Average milksolids price ($/kg MS)	3.60	3.70	3.76	3.82	3.87	3.93	4.20	4.25	4.31	4.37	4.47	4.54
Milk flow at peak month (% of total production)	13.1	12.8	12.5	12.2	11.9	12.0	13.0	12.6	12.3	11.2	11.6	11.7
Peak month	Oct	Oct	Nov	Nov	Nov	Nov	Oct	Oct	Nov	Nov	Feb	Feb

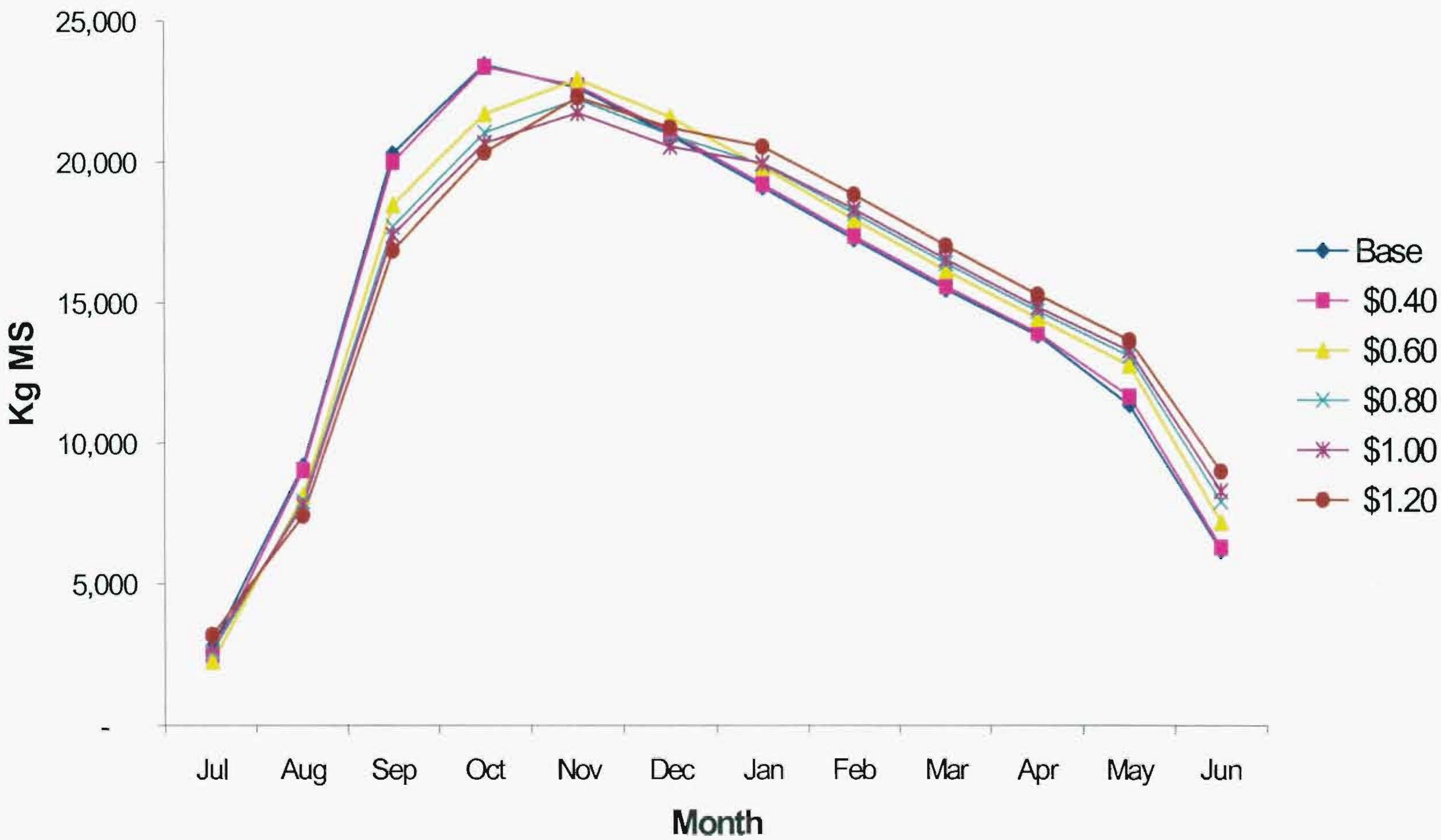


Figure 5.18: Milk supply patterns resulting from varying levels of shoulder premiums under a base payout of $3.6/kg MS

5.4.3 Schemes Involving Shoulder and Winter Premiums

These schemes represent more complex pricing regimes involving both shoulder and winter premiums. The alternatives considered in this study under both milksolids prices are presented in Table 5.9. Table 5.10 summarises the plans obtained for each of these schemes. Full details of the plans generated are included in Appendix D.

Table 5.9: Pricing schemes involving shoulder and winter premiums ($/kg MS) under two base milksolids prices

	Base price = $3.6/kg MS				Base price = $4.2/kg MS			
	Scheme				Scheme			
	A	B	C	D	E	F	G	H
July	3.90	4.20	4.50	4.80	4.35	4.50	4.65	4.80
August	3.80	4.00	4.20	4.40	4.30	4.40	4.50	4.60
September	3.60	3.60	3.60	3.60	4.20	4.20	4.20	4.20
October	3.60	3.60	3.60	3.60	4.20	4.20	4.20	4.20
November	3.60	3.60	3.60	3.60	4.20	4.20	4.20	4.20
December	3.80	4.00	4.20	4.40	4.30	4.40	4.50	4.60
January	3.80	4.00	4.20	4.40	4.30	4.40	4.50	4.60
February	3.80	4.00	4.20	4.40	4.30	4.40	4.50	4.60
March	3.80	4.00	4.20	4.40	4.30	4.40	4.50	4.60
April	3.80	4.00	4.20	4.40	4.30	4.40	4.50	4.60
May	3.90	4.20	4.50	4.80	4.35	4.50	4.65	4.80
June	3.90	4.20	4.50	4.80	4.35	4.50	4.65	4.80

Reference to table 5.10 will show that the plans obtained for the various schemes show similar trends as those obtained for winter premiums (Table 5.7), under the respective base milksolids prices. Thus, as the levels of both shoulder and winter premiums increase, the number of cows calving in spring decreases while the number of cows calving in summer and autumn increases. These changes also reduce peak milk flows, and make the peak month shift from October to May. However, compared with the situation under winter premiums, similar reductions in the peak are associated with much higher increases in the average milksolids price. Thus, under $3.6 /kg MS, a peak reduction of about 2.9% is associated with a milksolids price increase of 15%; under $4.2/kg MS, a peak reduction of about 2.7% is achieved at the expense of increasing the average milksolids price by 4%. Figure 5.18 illustrates the supply curves of the plans under $3.6/kg MS. The graph showing the supply curves of plans under $4.2 is included in Appendix D.

Table 5.10: Optimal plans for schemes involving shoulder and winter premiums under two base milksolids prices

	Base price = \$3.6/kg MS					Base Price = \$4.2/kg MS				
	Scheme					Scheme				
	Base	A	B	C	D	Base	E	F	G	H
Stocking rate (Cows/ha)	2.46	2.51	2.60	2.82	3.54	2.62	2.62	2.88	4.00	4.00
Cows calving in the month of (% of total)										
July	-	-	-	-	-	-	-	-	-	-
August	67	64	45	-	-	67	57	18	-	-
September	33	19	30	33	-	33	30	28	-	-
October	-	8	-	-	-	-	-	-	-	-
November	-	8	16	10	25	-	7	15	17	17
December	-	-	-	25	8	-	-	5	17	17
January	-	-	-	-	13	-	-	-	12	12
February	-	-	-	7	10	-	-	7	19	19
March	-	-	4	6	11	-	5	5	13	13
April	-	-	5	20	32	-	-	21	21	21
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
Total supplements (kg DM/cow)	122	147	219	882	1,718	236	243	759	2,180	2,180
Total Gross Margin (\$)	278,490	309,240	335,840	367,410	408,100	389,870	407,180	420,750	437,580	465,920
Average variable production cost (\$/kg MS)	2.05	2.06	2.13	2.37	2.79	2.17	2.18	2.37	2.99	2.99
Average milksolids price (\$/kg MS)	3.60	3.74	3.90	4.15	4.37	4.20	4.27	4.37	4.49	4.59
Milk flow at peak month (% of total production)	13.1	12.5	12.2	10.2	11.5	13.0	12.2	10.3	11.5	11.5
Peak month	Oct	Nov	Nov	Dec	May	Oct	Nov	Nov	May	May

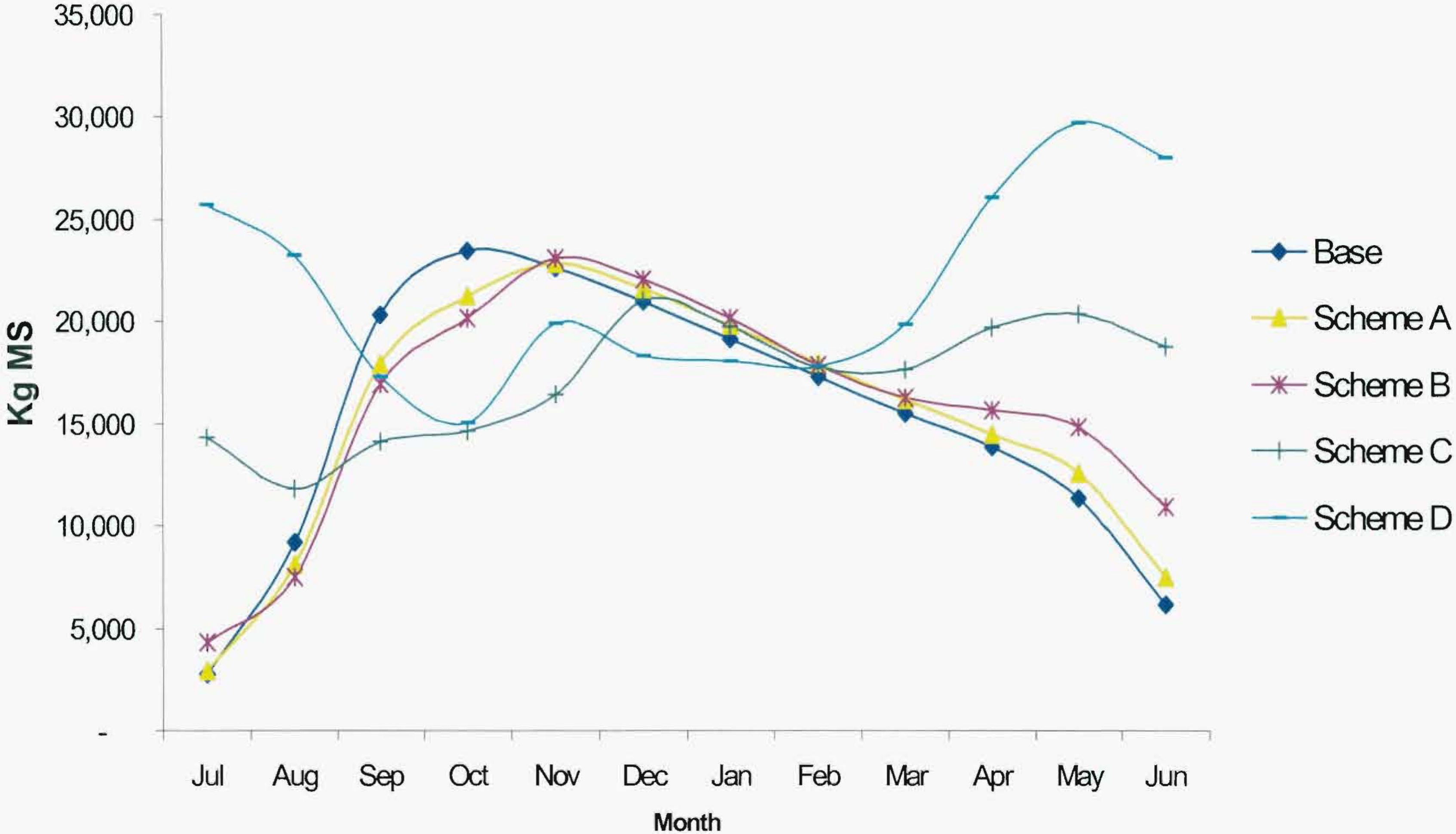


Figure 5.19: Milk supply patterns resulting from pricing schemes involving shoulder and winter premiums under a base milksolids price of 3.6/kg MS

5.4.4 Discussion of Seasonal Pricing Schemes

These results indicate that seasonal pricing schemes involving winter premiums would be the most cost effective means of encouraging farmers to change their milk supply patterns. A possible explanation of this is that farmers would necessarily need to move away from seasonal production in order to capture the winter premiums, whereas in the case of schemes involving shoulder premiums, farmers would be able to capture some of the premiums without changing their farm management practices. Table 5.11 summarises the effect of the pricing schemes considered upon peak milk flows and average milksolids prices.

Table 5.11: Effect of the different pricing schemes on peak milk flows and average milksolids prices

Base price	Schemes	Lowest peak obtained (% of total)	Average milksolids price ($/kg MS)
$3.6/kg MS	Winter premiums	10.8	3.90
	Shoulder premiums	11.9	3.87
	Shoulder + Winter	10.2	4.15
$4.2/kg MS	Winter premiums	10.2	4.31
	Shoulder premiums	11.2	4.37
	Shoulder + Winter	10.3	4.37

It will be recalled that the lactation curves for a given lactation length and level of milksolids production were assumed in the model to be the same for any calving date (see Chapter 3). However, several studies have shown that calving date has a major influence on the pattern of milk production (Eichler, 1996; Pinares & Holmes, 1996; Auldist *et al.*, 1997; Auldist *et al.*, 2002; Garcia *et al.*, 1998). In these trials, autumn calving cows consistently showed much flatter lactation curves than spring calving cows. Auldist *et al.* (2002) also compared the lactation curves of spring and summer calving cows, and found out that the latter had flatter lactation curves than the former. As the optimal plans for the pricing schemes considered in this study involve varying proportions of the herd calving in summer and autumn, in reality the reductions in the peak milk flows resulting from these schemes are likely to be higher than the figures presented in Tables 5.7, 5.8, 5.10, and 5.11.

Implementation of seasonal price incentives will mean that those farmers who contribute more significantly to peak milk volumes would receive a lower payout for the season compared to those farmers who pursue the incentives. The farmer's opportunity to benefit from the incentives will depend upon his ability to maximise the amount of milk qualifying for the premiums. Thus, the more milksolids produced during the incentive period the higher the average payout for the season.

The initial concern of the farmer who attempts to maximize the financial benefits available under an incentive scheme is the likely additional costs that would be incurred. Whilst in this study theoretical estimations of these costs were calculated for a case study farm, a great deal of variation may exist between individual farms. Therefore, each farmer would need to assess the resources available on his farm to successfully benefiting from the incentives before modifying his management system. Factors such as the levels of the seasonal premiums, the availability, quality, and cost of supplements, and the costs of extra infrastructure, such as feeding pads and tractors, all need to be considered.

A major problem of introducing seasonal pricing schemes is likely to be the inability of a large number of farmers to successfully produce out of season milk due to difficult climatic and physical conditions. These farmers would be at a distinct disadvantage since they could only realise the basic rate for the season. In a way, these farmers would be penalised because of their farm's locality. However, it can be argued that these same farmers contribute more significantly to peak milk volumes than farmers with smother supply curves.

CHAPTER 6

SUMMARY

6.1 Summary

The overall objective of this research was to explore economic aspects of changing the seasonality of milk production in New Zealand through changing farm management practices. In particular, this study aimed to explore different pricing schemes that could be implemented in New Zealand to reduce the seasonality of milk production, and to estimate the effects that such schemes might have upon farm management practices, milk supply patterns, and milk production costs, especially in the context of the South Island. To accomplish these objectives, a linear programming model of a South Island dairy farm was developed.

The main features of the New Zealand dairy industry were described in Chapter 2. Two factors were identified as underlying the economic position of the New Zealand dairy industry, namely, the pasture-based, seasonal milk production system, and its export orientation. It was highlighted that the reliance on grazed pasture as the main source of feed caused a highly seasonal milk production pattern. The particular characteristics of dairy production in the South Island were also discussed. It was indicated that shorter periods of pasture growth relative to the North Island are compensated by the availability of high quality, relatively cheap supplements, and that some areas in the South Island are ideal for out of season milk production. Finally, it was highlighted that the dynamic growth in milk production in the South Island is placing a heavy pressure on the milk processing factories to absorb the increased peak milk flow.

In Chapter 3 the structure of the linear programming model developed for this research was described, and the relationships assumed for the model were discussed. Chapter 4 contained a description of the procedures used in evaluating the model. The model was evaluated through verification and validation. Two types of experiments were applied to the model, namely partial tests and prediction experiments, using data from the case study farm. . It was concluded that the model was adequate for its purpose.

In chapter 5 the experiments that were carried out with the model were described, and the results obtained were discussed. Experimentation proceeded in three phases. The first phase involved generating optimal plans for the case study farm under the pricing scheme currently used in New Zealand (i.e. the same milksolids price for every month of the year). Plans were obtained for four milksolids prices ($3, $3.6, $4.2, and $4.8/kgMS), to reflect the variability in milksolids prices observed in recent years. The purpose of these initial experiments was to gain an understanding of the economics of seasonal milk production systems, to better appreciate the implications of moving away from seasonal production. These plans represented dairying systems that would be optimal under the pricing scheme currently used in New Zealand, and provided a base to compare the physical and economic characteristics of plans generated in subsequent experiments.

In the second phase, the model was used to explore farming systems for spreading milk supply patterns and to calculate the costs of producing milk from these systems, under the four milksolids prices considered in phase one. Thus, systems involving split calving a herd (spring and autumn) were simulated by forcing increasing proportions of the herd to calve in autumn. These plans were then compared to the optimal plans generated in phase one.

Finally, the third phase involved simulating different payment systems that could be implemented in New Zealand to reduce the seasonality of milk supply. Three types of seasonal pricing schemes were considered, namely, schemes involving winter premiums, schemes involving shoulder premiums, and complex schemes involving both shoulder and winter premiums. By changing the milk prices in the objective function and re-running the model iteratively, the farm management implications of differential pricing systems were predicted, and the premiums that would be required to encourage farmers to change their milk supply patterns were estimated. Also, by considering varying base milksolids prices, the effect of the base milksolids price upon the required premiums were estimated. The conclusions drawn from these experiments are summarised next.

6.2 Conclusions

The results of the initial experiments emphasised that, under the current pricing system in New Zealand, the seasonal, pasture based production system is well justified on economic grounds. This system ensures a close synchrony between pasture demand by the cows and pasture supply. Nitrogen fertilizer was an important source of extra feed, being applied at the shoulders of the season, thus producing a more even pasture production curve. The higher N application rates in the autumn relative to the spring indicated that the model used N to provide extra late lactation pasture. The model consistently predicted that, even under low MS prices, the optimal strategy would be to have cows with long lactations and, thus, high MS yields per lactation. As the milk price increased, the plans showed increasing levels of intensification, driven by higher stocking rates, with less reliance on pasture, and greater use of purchased supplements. To explore the economic reasons for choosing a longer lactation under varying MS prices, further model runs were made to compare the base optimal plans with plans involving cows with shorter lactations and therefore lower MS yields, which tend to represent the current practice in New Zealand. It was concluded that, compared to the current situation, more milk could be supplied outside the peak at no extra cost, because of the economic advantage of feeding the cows to achieve longer lactations and higher MS production. Therefore, no premiums would be required to encourage farmers to pursue such a practice, since it would be a more profitable alternative than the traditional system involving cows with short lactations. However, it was also concluded that extending lactation would have only a marginal effect upon increasing milk throughput outside the peak period. Thus, a significant reduction in the seasonality of milk production would require adopting different calving dates.

The results of the second phase of the experiments carried out with the model showed that, as the proportion of the herd calving in autumn increased, the mismatch between the patterns of pasture demand and growth worsened. Consequently, increasing amounts of pasture were conserved and more supplements were purchased. The increased feeding costs, as well as the extra costs associated with winter milk production, caused sharp drops in profit. The reduction in profit relative to the base plan, under each of the base milksolids prices considered, was interpreted as the cost of moving away from seasonal production. It was concluded that the base milksolids price has an important effect on the costs of changing milk supply patterns, and hence, on the price incentives that would be required to compensate for such costs. However, it was also noted that the key factor driving this effect was not the milksolids price on its own, but the relationship between this price and input costs, particularly supplements.

The results of the third phase of the experimentation carried out with the model indicated that seasonal pricing schemes involving winter premiums would be the most cost effective means of encouraging farmers to change their milk supply patterns. A possible explanation of this would be that farmers would necessarily need to move away from seasonal production in order to capture the winter premiums, whereas in the case of schemes involving shoulder premiums, farmers would be able to capture some of the premiums without changing their farm management practices. It was also concluded that, as the base milksolids price increases relative to input costs, lower premiums would be required to encourage farmers to change their milk supply patterns.

6.3 Limitations of the Study and Suggestions for Further Research

This study used a linear programming model developed with data from a South Island case study dairy farm. This approach assumes that the results generated for the case study farm can be applied to other farms in the region, and therefore, aggregate implications can be inferred with reasonably accuracy. However, all farms differ in respect to the quantity and quality of their resources. Therefore, conclusions drawn from an analysis of one farm can only absolutely apply to that farm (Nuthall, 1967).

There are populations, however, where the differences between farms are small, so that a study of one farm can give results largely applicable to the other units in the population. Consequently, the study could have been given greater scope if farms of a given region (The South Island, in this case) had been divided by factors considered important so that the variance within groups had been sufficiently small to enable research results from a modal farm within each strata to apply to the group as a whole. For instance, the South Island could be divided into sub-regions with similar physical and climatic characteristics, such as Canterbury, Southland, the West Coast, etc. A case study farm would then be selected from each sub-region, and different runs of the model would be made based on the parameters specific to the respective case study farms. This way, the implications of these results for the South Island as a whole would be ascertained with greater accuracy. It can be considered, therefore, that the results presented in this thesis apply specifically to farms in the Canterbury region, with similar soils and climate where the case study farm is located. Implications for the South Island in general cannot be determined safely, given the great variability between the various sub-regions.

This study showed that moving away from seasonal production will increase production costs, mainly through increased feeding costs. Whilst this study made theoretical estimations of these costs, a great deal of variation often exists between individual farms and regional averages. Therefore, each farmer would need to assess the resources available on his farm to successfully benefiting from seasonal price incentives before modifying his management system. Factors such as the levels of the seasonal premiums, the availability, quality, and cost of supplements, and the costs of extra infrastructure, such as feeding pads and tractors, all need to be considered.

This assessment, however, may be significantly influenced by a host of socio-economic factors, such as his willingness to milk for longer periods and during difficult stages of the season. It could be hypothesised, therefore, that different farmers will respond to the same signals differently depending on their personal goals and life style preferences. Thus, although farmers may be confident that the economic costs of producing out of season milk would be significantly outweighed by the additional returns brought about by the price incentives, it is the farmers' assessment of the social costs that would be incurred by changes in farm management practices that will be critical to the success of any incentive scheme. This study did not consider these factors. Accordingly, future research on this topic should also elicit farmers' attitudes to out of season milk production.

This study was confined to estimating the increased production costs associated with alternative milk supply patterns, and the premiums that would be required to encourage such supply curves. It was left to the processing sector to determine whether the savings in collection and processing costs, as well as the increased returns from a better product mix, would outweigh the increased production costs at the farm level. Had information related to the processing sector been available, this research could have found the milk supply pattern that would offer the greatest profit to the dairy industry as a whole. Thus, the linear programming model developed during this study could have been expanded to include variables related to the processing sector. Therefore, this is something worthy of consideration for further research on this topic.

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APPENDIX A

Physical Data: Calculation of the Nutritional Requirements of the Cows

These requirements were based on data sourced from ARC (1980), NRC (1989), and Holmes *et al.* (2002). Following the latter authors, the factorial approach was used. Thus, the requirements for the separate processes of maintenance, liveweight gain, milk production, walking, and pregnancy were estimated and then summed. The daily nutritional requirements were then aggregated into fortnightly requirements.

A.1 ME Requirements of Milking Cows

These figures assume that the herd is being fed high quality feed (i.e. > 11 MJME/kg DM). Daily ME requirements increase if poorer quality feed is being used, because of lower energy utilisation efficiency (ARC, 1980). The ME requirements assumed for lactating cows are shown in table A.1.

Table A.1: ME requirements of milking cows

Process	ME requirement per day
Maintenance	0.60 MJ / Kg LW $^{0.75}$
Liveweight gain	40 MJ / Kg LWG
Liveweight loss[3]	-30 MJ / Kg MS
MS production	65 MJ / Kg MS
Walking[4]	2 MJ / day
Pregnancy	Refer to table A.2

Source: ARC, 1980; NRC, 1989

[3] If cows are losing weight, energy is released, which can be used either for maintenance or for milk production. However, the conversion of liveweight to ME is not completely efficient. Thus, 1 kg of LW gain requires 40 MJ ME, whereas 1 kg LW loss releases only 30 MJ ME.

[4] Australian figures suggest that a cow uses 1 MJ ME to walk 1 kilometre on flat land (Hughes, pers. comm.). Thus, assuming a cow walks 2 km per day, the ME requirement is increased by 2 MJ.

In early pregnancy, the growing calf requires little extra energy for its mother to grow (Holmes *et al.*, 2002). However, for the last 4 months of pregnancy, the energy demands increase sharply, as shown in table A.2.

Table A.2: ME requirements for pregnancy

	Month of Pregnancy				
	1 – 5	6	7	8	9
MJ ME / d	0	5	10	20	30

Source: Holmes *et al.* (2002)

A.2 ME Requirements of Dry Cows

The assumed ME requirements of dry cows are shown in table A.3.

Table A.3: ME requirements of dry cows

Process	**ME requirement per day**
Maintenance	0.55 MJ / Kg LW $^{0.75}$
Liveweight gain[5]	46 MJ / Kg LWG
Pregnancy	Refer to table A.2

Source: ARC, 1980; NRC, 1989

These figures are based on the assumption that the cows are fed high quality feed (i.e. > 11 MJ ME/kg DM).

Lactation length determines the duration of the dry period, which in turn determines the total ME requirement during the dry period. Thus, a cow with a lactation length of 270 days requires approximately 9800 MJ ME during the dry period, whereas a cow with a lactation length of 300 days requires only 7800 MJ ME, due to a shorter dry period (Refer to section A.5.2). This requirement can be met either by grazing the cow on the farm (thus consuming pasture in the appropriate sub-periods) or by grazing the cow off the farm, at a cost. The home

[5] Dry cows need more energy to gain liveweight than milking cows, because they use feed less efficiently for liveweight gain when they are not in lactation (Holmes *et al.*, 2002).

grazing option incurs an opportunity cost, which arises due to the consumption of pasture that could otherwise have been eaten by milking cows. The amount of pasture consumed by dry cows grazed on the farm was estimated by dividing the total ME requirements during the dry period by the assumed ME content of the pasture (i.e. 11 MJ ME / kg pasture DM). This amount of pasture was assumed to be grazed evenly throughout the dry period. Table A.4 shows the estimated pasture consumption patterns of two cows calving on the same date but with different lactation lengths.

Table A.4: Estimated pasture consumption during the dry period of two cows calving on the same date but with different lactation lengths

		Sub-period	Cow with lactation length of 270 days	Cow with lactation length of 300 days
ME dry period Cow k	(MJ)		9,800	7,800
Pasture * Reconciliation rows	(kg DM)	t-2	150	
		t-1	150	
		t	150	177
		t+1	150	177
		t+2	150	177
		t+3	150	177

*** Assumes pasture quality of 11 MJ ME / kg DM**

A.3 CP Requirements of Milking Cows

The CP requirements of milking cows were calculated using software developed by the NRC (1989). Inputs such as liveweight, liveweight change, MS production, and number of days into pregnancy were entered and the software calculated the daily CP requirements. These daily requirements were then aggregated into fortnightly requirements using a spreadsheet (Refer to section A.5.4).

A.4 Dry Matter Intake

To calculate the maximum dry matter intake per day, the simplified approach of Miller (1982) was adopted. Thus, the intake limit was assumed to be a function of liveweight alone, not being affected by food source. Accordingly, the dry matter intake limit, expressed as a percentage of bodyweight, was taken to increase from 2.5% during the dry period to 4.0% at peak lactation, and then to fall until the end of lactation. The daily intake limits were then aggregated into fortnightly sub-periods. The pattern assumed is shown in figure A.1.

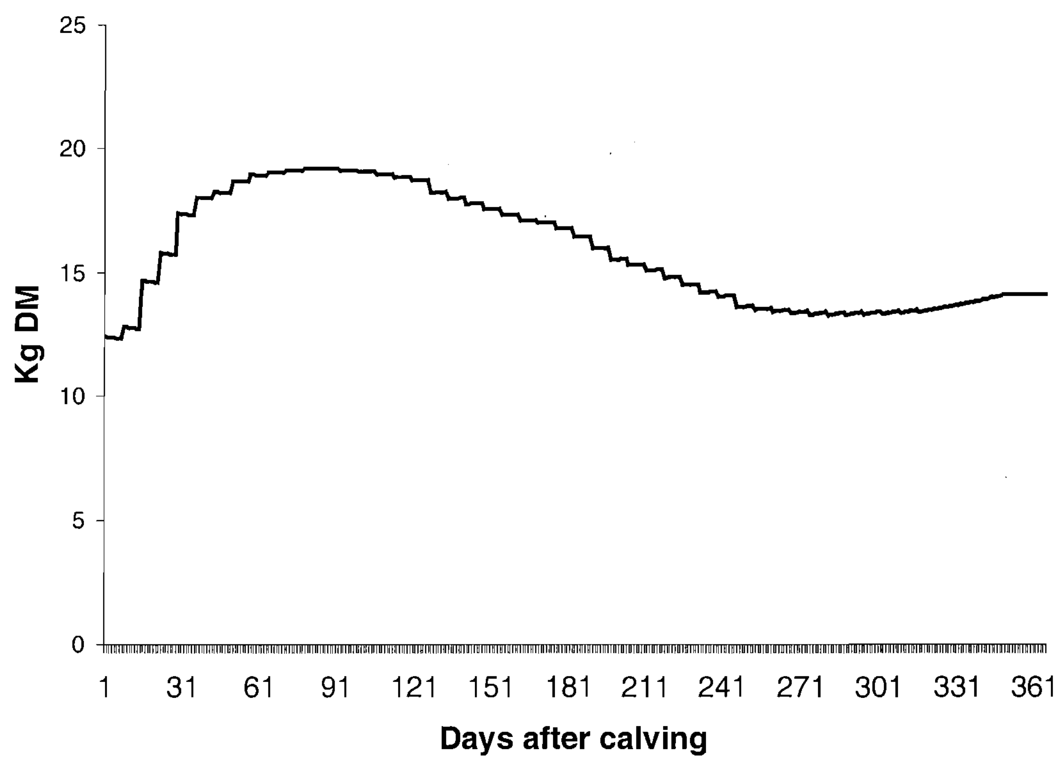


Figure A.1: Assumed Dry Matter Intake Pattern

A.5 An Example

The calculation of both the ME and CP requirements of one of the cow activities included in the model is presented below to illustrate the procedures used. The example cow calves in sub-period 1 (July 1st), has a lactation length of 270 days, and produces 370 kg MS per lactation.

A.5.1 Calculation of the Liveweight Change and Milksolids Production Patterns

A model, developed by Brooks (1993), which predicts a cow's lactation and liveweight pattern for a given lactation length, milk production level, and condition score (CS) at calving, was used. The output of the model is illustrated in table A.5.

Table A.5: Calculation of the LW change and MS production patterns of the example cow

COWREQTS:BY I.M.BROOKES.DEPT. of ANIMAL SCIENCE,MASSEY UNIVERSITY				
NAME:	Example	MONTH OF CALVING: (1st Half=1,2nd Half=2):		7 1
BREED (F=1,J=2,FxJ=3):	1		DAYS AFTER CALVING	COND SCORE
LWT AT COND.SCORE 5:	550 Kg	CALVING:	0	5.00
-		PEAK MILK YIELD:	42	4.50
ANNUAL MILKSOLIDS		DRYING-OFF:	270	4.40
YIELD (Kg):	370 Kg	NEXT CALVING:	365	5

	DAYS	MILK SOLIDS Kg/day	MILK SOLIDS Kg/half month	CS	LWT
TOTAL:		370			
JULY(1)	8	1.45	22.03	4.91	546
JULY(2)	23	1.67	25.39	4.73	539
AUG(1)	38	1.72	26.13	4.55	532
AUG(2)	53	1.71	26.00	4.50	530
SEP(1)	68	1.67	25.45	4.49	530
SEP(2)	84	1.62	24.67	4.48	530
OCT(1)	99	1.56	23.76	4.48	530
OCT(2)	114	1.50	22.78	4.47	530
NOV(1)	129	1.43	21.76	4.46	530
NOV(2)	144	1.36	20.73	4.46	530
DEC(1)	160	1.30	19.71	4.45	531
DEC(2)	175	1.23	18.71	4.44	532
JAN(1)	190	1.17	17.73	4.44	534
JAN(2)	205	1.10	16.78	4.43	536
FEB(1)	221	1.04	15.87	4.42	538
FEB(2)	236	0.99	14.99	4.42	541
MARCH(1)	251	0.93	14.14	4.41	545
MARCH(2)	266	0.88	13.34	4.40	550
APRIL(1)	281	0.00	0.00	4.47	558
APRIL(2)	297	0.00	0.00	4.57	569
MAY(1)	312	0.00	0.00	4.66	580
MAY(2)	327	0.00	0.00	4.76	593
JUNE(1)	342	0.00	0.00	4.86	606
JUNE(2)	357	0.00	0.00	4.95	621

A.5.2 Calculation of the Daily ME Requirements

The information contained in table A.4 was then used to calculate the ME requirements of the example cow. A spreadsheet, programmed with appropriate formulae, was used for this purpose. A section of the spreadsheet is presented in table A.6.

Table A.6: Partial representation of the spreadsheet that was programmed to calculate ME requirements.

			MJ ME						
Date	Days preg.	LW	LW change/day	MAINTENANCE	WALKING	LWG	PREGNANCY	MS	Total
20-Feb	151.00	491.00	0.25	62.58	2.00	9.84	5.00	64.05	143.47
21-Feb	152.00	491.24	0.25	62.61	2.00	9.84	5.00	64.05	143.49
22-Feb	153.00	491.49	0.25	62.63	2.00	9.84	5.00	64.05	143.52
23-Feb	154.00	491.73	0.25	62.65	2.00	9.84	5.00	64.05	143.54
24-Feb	155.00	491.98	0.25	62.68	2.00	9.84	5.00	64.05	143.56
25-Feb	156.00	492.22	0.25	62.70	2.00	9.84	5.00	64.05	143.59
26-Feb	157.00	492.47	0.25	62.72	2.00	9.84	5.00	64.05	143.61
27-Feb	158.00	492.72	0.25	62.75	2.00	9.84	5.00	64.05	143.63
28-Feb	159.00	492.96	0.25	62.77	2.00	9.84	5.00	64.05	143.66
1-Mar	160.00	493.21	0.25	62.79	2.00	9.84	5.00	60.45	140.08
2-Mar	161.00	493.51	0.30	62.82	2.00	11.91	5.00	60.45	142.19
3-Mar	162.00	493.80	0.30	62.85	2.00	11.91	5.00	60.45	142.22
4-Mar	163.00	494.10	0.30	62.88	2.00	11.91	5.00	60.45	142.24
5-Mar	164.00	494.40	0.30	62.91	2.00	11.91	5.00	60.45	142.27
6-Mar	165.00	494.70	0.30	62.94	2.00	11.91	5.00	60.45	142.30
7-Mar	166.00	494.99	0.30	62.97	2.00	11.91	5.00	60.45	142.33
8-Mar	167.00	495.29	0.30	62.99	2.00	11.91	5.00	60.45	142.36
9-Mar	168.00	495.59	0.30	63.02	2.00	11.91	5.00	60.45	142.39
10-Mar	169.00	495.89	0.30	63.05	2.00	11.91	5.00	60.45	142.41
11-Mar	170.00	496.19	0.30	63.08	2.00	11.91	5.00	60.45	142.44
12-Mar	171.00	496.48	0.30	63.11	2.00	11.91	5.00	60.45	142.47
13-Mar	172.00	496.78	0.30	63.14	2.00	11.91	5.00	60.45	142.50
14-Mar	173.00	497.08	0.30	63.16	2.00	11.91	5.00	60.45	142.53
15-Mar	174.00	497.38	0.30	63.19	2.00	11.91	5.00	57.02	139.12
16-Mar	175.00	497.85	0.47	63.24	2.00	18.89	5.00	57.02	146.15
17-Mar	176.00	498.32	0.47	63.28	2.00	18.89	5.00	57.02	146.19
18-Mar	177.00	498.79	0.47	63.33	2.00	18.89	5.00	57.02	146.24
19-Mar	178.00	499.27	0.47	63.37	2.00	18.89	5.00	57.02	146.28
20-Mar	179.00	499.74	0.47	63.42	2.00	18.89	5.00	57.02	146.33
21-Mar	180.00	500.21	0.47	63.46	2.00	18.89	5.00	57.02	146.37
22-Mar	181.00	500.68	0.47	63.51	2.00	18.89	10.00	57.02	151.42
23-Mar	182.00	501.15	0.47	63.55	2.00	18.89	10.00	57.02	151.46
24-Mar	183.00	501.63	0.47	63.60	2.00	18.89	10.00	57.02	151.51
25-Mar	184.00	502.10	0.47	63.64	2.00	18.89	10.00	57.02	151.55
26-Mar	185.00	502.57	0.47	63.69	2.00	18.89	10.00	57.02	151.60
27-Mar	186.00	503.04	0.47	63.73	2.00	18.89	10.00	57.02	151.64
28-Mar	187.00	503.52	0.47	63.78	2.00	18.89	10.00	57.02	151.69

A.5.3 Aggregation of Daily ME Requirements into Fortnightly Requirements

Finally, the daily ME requirements were aggregated into fortnightly requirements, so that they could be incorporated into the model. Table A.7 shows the ME requirements per sub-period. The cells in grey correspond to the requirements during the dry period.

Table A.7: ME requirements aggregated per fortnightly sub-period (Example cow, producing 370 kg MS per lactation, with a lactation length of 270 days.

Sub-period	Starting	MJ ME
1	1-Jul	2,007.86
2	15-Jul	2,235.80
3	29-Jul	2,349.71
4	12-Aug	2,424.17
5	26-Aug	2,425.05
6	9-Sep	2,387.06
7	23-Sep	2,342.07
8	7-Oct	2,289.57
9	21-Oct	2,247.07
10	4-Nov	2,194.89
11	18-Nov	2,148.27
12	2-Dec	2,103.07
13	16-Dec	2,053.97
14	30-Dec	2,026.04
15	13-Jan	1,980.53
16	27-Jan	1,963.04
17	10-Feb	1,965.05
18	24-Feb	1,996.42
19	10-Mar	2,031.90
20	24-Mar	1,626.16
21	7-Apr	1,420.40
22	21-Apr	1,581.25
23	5-May	1,664.76
24	19-May	1,751.44
25	2-Jun	1,934.21
26	16-Jun	1,405.22

A.5.4 Calculation of the Daily CP Requirements

Table A.8 shows the daily CP requirements of the example cow, for the period between 20[th] February and 28[th] March, calculated using software developed by the NRC (1989). Protein requirements during the dry period were not calculated, since protein is unlikely to be a limiting nutrient in the ration of dry cows under New Zealand conditions.

Table A.8: Partial representation of the calculation of the daily CP requirements of the example cow, producing 370 kg MS per lactation, with a lactation length of 270 days.

Date	Days preg.	LW	LW change(kg/day)	MS (kg MS/day)	CP (kg/day)
20-Feb	151.00	491.00	0.25	1.04	1.99
21-Feb	152.00	491.24	0.25	1.04	1.99
22-Feb	153.00	491.49	0.25	1.04	1.99
23-Feb	154.00	491.73	0.25	1.04	1.99
24-Feb	155.00	491.98	0.25	1.04	1.99
25-Feb	156.00	492.22	0.25	1.04	1.92
26-Feb	157.00	492.47	0.25	1.04	1.92
27-Feb	158.00	492.72	0.25	1.04	1.92
28-Feb	159.00	492.96	0.25	1.04	1.92
1-Mar	160.00	493.21	0.25	0.00	1.92
2-Mar	161.00	493.51	0.30	0.99	1.92
3-Mar	162.00	493.80	0.30	0.99	1.92
4-Mar	163.00	494.10	0.30	0.99	1.92
5-Mar	164.00	494.40	0.30	0.99	1.92
6-Mar	165.00	494.70	0.30	0.99	1.92
7-Mar	166.00	494.99	0.30	0.99	1.92
8-Mar	167.00	495.29	0.30	0.99	1.92
9-Mar	168.00	495.59	0.30	0.99	1.92
10-Mar	169.00	495.89	0.30	0.99	1.92
11-Mar	170.00	496.19	0.30	0.99	1.88
12-Mar	171.00	496.48	0.30	0.99	1.88
13-Mar	172.00	496.78	0.30	0.99	1.88
14-Mar	173.00	497.08	0.30	0.99	1.88
15-Mar	174.00	497.38	0.30	0.00	1.88
16-Mar	175.00	497.85	0.47	0.93	1.88
17-Mar	176.00	498.32	0.47	0.93	1.88
18-Mar	177.00	498.79	0.47	0.93	1.88
19-Mar	178.00	499.27	0.47	0.93	1.88
20-Mar	179.00	499.74	0.47	0.93	1.88
21-Mar	180.00	500.21	0.47	0.93	1.88
22-Mar	181.00	500.68	0.47	0.93	1.88
23-Mar	182.00	501.15	0.47	0.93	1.88

A.5.5 Aggregation of the Daily CP Requirements into Fortnightly Requirements

Finally, the daily CP requirements were aggregated into fortnightly requirements, so that they could be incorporated into the model. Table A.9 shows the CP requirements per sub-period.

Table A.9: CP requirements aggregated per fortnightly sub-period (example cow, producing 370 kg MS per lactation, with a lactation length of 270 days).

Sub-period	Starting	Kg CP
1	1-Jul	30.66
2	15-Jul	33.70
3	29-Jul	34.16
4	12-Aug	34.19
5	26-Aug	33.87
6	9-Sep	33.26
7	23-Sep	32.60
8	7-Oct	31.73
9	21-Oct	31.02
10	4-Nov	30.15
11	18-Nov	29.37
12	2-Dec	28.53
13	16-Dec	27.82
14	30-Dec	27.06
15	13-Jan	26.44
16	27-Jan	25.79
17	10-Feb	25.27
18	24-Feb	24.87
19	10-Mar	24.48
20	24-Mar	17.70
21	7-Apr	–
22	21-Apr	–
23	5-May	–
24	19-May	–
25	2-Jun	–
26	16-Jun	–

Figure A.2 depicts the assumed MS production and liveweight change patterns, as well as the daily ME and CP requirements calculated previously for the example cow.

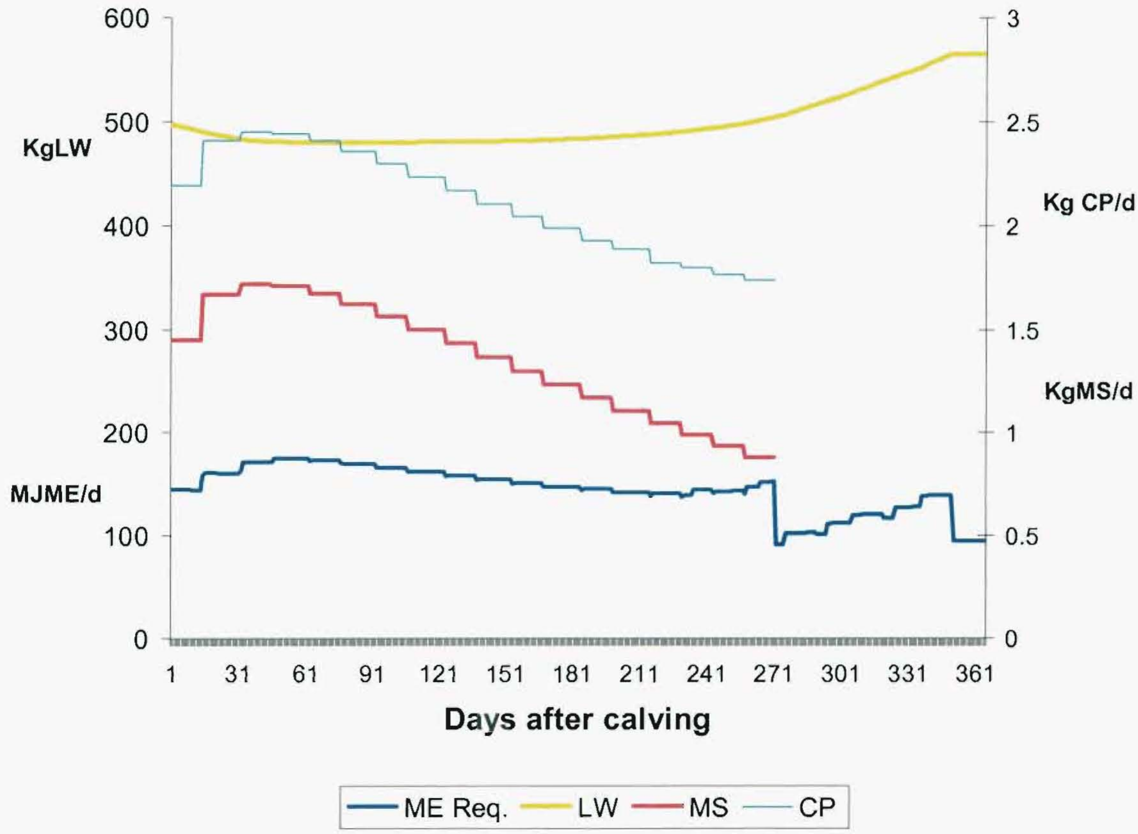


Figure A.2: Daily MS production, LW change, and ME requirements of the example cow.

A.6 Nutritional Requirement Profiles for Different Production Levels and Lactation Lengths

A.6.1 Cow producing 370 Kg MS per lactation; lactation length: 270 days

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (kg)	LW change (kg/day)	MS (kg/day)	Maintenance	Walking	LWG	Preg.	MS	Total	(kg/day)
1	496.38	-0.52	1.45	63.10	2.00	-15.52		94.16	143.74	2.19
2	495.86	-0.52	1.45	63.05	2.00	-15.52		94.16	143.69	2.19
3	495.34	-0.52	1.45	63.00	2.00	-15.52		94.16	143.64	2.19
4	494.83	-0.52	1.45	62.95	2.00	-15.52		94.16	143.59	2.19
5	494.31	-0.52	1.45	62.90	2.00	-15.52		94.16	143.54	2.19
6	493.79	-0.52	1.45	62.85	2.00	-15.52		94.16	143.49	2.19
7	493.28	-0.52	1.45	62.80	2.00	-15.52		94.16	143.44	2.19
8	492.76	-0.52	1.45	62.75	2.00	-15.52		94.16	143.39	2.19
9	492.24	-0.52	1.45	62.70	2.00	-15.52		94.16	143.34	2.19
10	491.72	-0.52	1.45	62.65	2.00	-15.52		94.16	143.30	2.19
11	491.21	-0.52	1.45	62.60	2.00	-15.52		94.16	143.25	2.19
12	490.69	-0.52	1.45	62.55	2.00	-15.52		94.16	143.20	2.19
13	490.17	-0.52	1.45	62.50	2.00	-15.52		94.16	143.15	2.19
14	489.65	-0.52	1.45	62.46	2.00	-15.52		94.16	143.10	2.19
15	489.14	-0.52	1.67	62.41	2.00	-15.52		108.54	157.42	2.41
16	488.71	-0.43	1.67	62.36	2.00	-12.78		108.54	160.12	2.41
17	488.28	-0.43	1.67	62.32	2.00	-12.78		108.54	160.08	2.41
18	487.86	-0.43	1.67	62.28	2.00	-12.78		108.54	160.04	2.41
19	487.43	-0.43	1.67	62.24	2.00	-12.78		108.54	160.00	2.41
20	487.01	-0.43	1.67	62.20	2.00	-12.78		108.54	159.96	2.41
21	486.58	-0.43	1.67	62.16	2.00	-12.78		108.54	159.92	2.41
22	486.15	-0.43	1.67	62.12	2.00	-12.78		108.54	159.88	2.41
23	485.73	-0.43	1.67	62.08	2.00	-12.78		108.54	159.83	2.41
24	485.30	-0.43	1.67	62.04	2.00	-12.78		108.54	159.79	2.41
25	484.88	-0.43	1.67	62.00	2.00	-12.78		108.54	159.75	2.41
26	484.45	-0.43	1.67	61.96	2.00	-12.78		108.54	159.71	2.41
27	484.02	-0.43	1.67	61.92	2.00	-12.78		108.54	159.67	2.41
28	483.60	-0.43	1.67	61.87	2.00	-12.78		108.54	159.63	2.41
29	483.17	-0.43	1.67	61.83	2.00	-12.78		108.54	159.59	2.41
30	482.75	-0.43	1.67	61.79	2.00	-12.78		108.54	159.55	2.41
31	482.32	-0.43	1.67	61.75	2.00	-12.78		108.54	159.51	2.41
32	481.89	-0.43	1.72	61.71	2.00	-12.78		111.69	162.63	2.45
33	481.75	-0.15	1.72	61.70	2.00	-4.48		111.69	170.91	2.45
34	481.60	-0.15	1.72	61.68	2.00	-4.48		111.69	170.89	2.45
35	481.45	-0.15	1.72	61.67	2.00	-4.48		111.69	170.88	2.45
36	481.30	-0.15	1.72	61.65	2.00	-4.48		111.69	170.87	2.45
37	481.15	-0.15	1.72	61.64	2.00	-4.48		111.69	170.85	2.45
38	481.00	-0.15	1.72	61.63	2.00	-4.48		111.69	170.84	2.45
39	480.85	-0.15	1.72	61.61	2.00	-4.48		111.69	170.82	2.45
40	480.70	-0.15	1.72	61.60	2.00	-4.48		111.69	170.81	2.45
41	480.55	-0.15	1.72	61.58	2.00	-4.48		111.69	170.79	2.45
42	480.40	-0.15	1.72	61.57	2.00	-4.48		111.69	170.78	2.45
43	480.25	-0.15	1.72	61.55	2.00	-4.48		111.69	170.77	2.45
44	480.10	-0.15	1.72	61.54	2.00	-4.48		111.69	170.75	2.45
45	479.95	-0.15	1.72	61.52	2.00	-4.48		111.69	170.74	2.45
46	479.80	-0.15	1.71	61.51	2.00	-4.48		111.14	170.17	2.44
47	479.79	-0.02	1.71	61.51	2.00	-0.47		111.14	174.18	2.44

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (kg)	LW change (kg/day)	MS (kg/day)	Maintenance	Walking	LWG	Preg.	MS	Total	(kg/day)
48	479.77	-0.02	1.71	61.51	2.00	-0.47		111.14	174.18	2.44
49	479.76	-0.02	1.71	61.51	2.00	-0.47		111.14	174.18	2.44
50	479.74	-0.02	1.71	61.50	2.00	-0.47		111.14	174.18	2.44
51	479.72	-0.02	1.71	61.50	2.00	-0.47		111.14	174.18	2.44
52	479.71	-0.02	1.71	61.50	2.00	-0.47		111.14	174.17	2.44
53	479.69	-0.02	1.71	61.50	2.00	-0.47		111.14	174.17	2.44
54	479.68	-0.02	1.71	61.50	2.00	-0.47		111.14	174.17	2.44
55	479.66	-0.02	1.71	61.50	2.00	-0.47		111.14	174.17	2.44
56	479.65	-0.02	1.71	61.50	2.00	-0.47		111.14	174.17	2.44
57	479.63	-0.02	1.71	61.49	2.00	-0.47		111.14	174.17	2.44
58	479.61	-0.02	1.71	61.49	2.00	-0.47		111.14	174.16	2.44
59	479.60	-0.02	1.71	61.49	2.00	-0.47		111.14	174.16	2.44
60	479.58	-0.02	1.71	61.49	2.00	-0.47		111.14	174.16	2.44
61	479.57	-0.02	1.71	61.49	2.00	-0.47		111.14	174.16	2.44
62	479.55	-0.02	1.71	61.49	2.00	-0.47		111.14	174.16	2.44
63	479.54	-0.02	1.67	61.48	2.00	-0.47		108.79	171.81	2.40
64	479.54	0.01	1.67	61.49	2.00	0.33		108.79	172.61	2.40
65	479.55	0.01	1.67	61.49	2.00	0.33		108.79	172.61	2.40
66	479.56	0.01	1.67	61.49	2.00	0.33		108.79	172.61	2.40
67	479.57	0.01	1.67	61.49	2.00	0.33		108.79	172.61	2.40
68	479.58	0.01	1.67	61.49	2.00	0.33		108.79	172.61	2.40
69	479.59	0.01	1.67	61.49	2.00	0.33		108.79	172.61	2.40
70	479.59	0.01	1.67	61.49	2.00	0.33		108.79	172.61	2.40
71	479.60	0.01	1.67	61.49	2.00	0.33		108.79	172.61	2.40
72	479.61	0.01	1.67	61.49	2.00	0.33		108.79	172.61	2.40
73	479.62	0.01	1.67	61.49	2.00	0.33		108.79	172.61	2.40
74	479.63	0.01	1.67	61.49	2.00	0.33		108.79	172.61	2.40
75	479.63	0.01	1.67	61.49	2.00	0.33		108.79	172.62	2.40
76	479.64	0.01	1.67	61.49	2.00	0.33		108.79	172.62	2.40
77	479.65	0.01	1.62	61.50	2.00	0.33		105.46	169.28	2.35
78	479.65	-0.00	1.62	61.50	2.00	-0.08		105.46	168.87	2.35
79	479.65	-0.00	1.62	61.50	2.00	-0.08		105.46	168.87	2.35
80	479.64	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
81	479.64	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
82	479.64	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
83	479.63	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
84	479.63	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
85	479.63	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
86	479.63	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
87	479.62	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
88	479.62	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
89	479.62	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
90	479.62	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
91	479.61	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
92	479.61	-0.00	1.62	61.49	2.00	-0.08		105.46	168.87	2.35
93	479.61	-0.00	1.56	61.49	2.00	-0.08		101.56	164.97	2.29
94	479.61	0.00	1.56	61.49	2.00	0.17		101.56	165.23	2.29
95	479.62	0.00	1.56	61.49	2.00	0.17		101.56	165.23	2.29
96	479.62	0.00	1.56	61.49	2.00	0.17		101.56	165.23	2.29
97	479.62	0.00	1.56	61.49	2.00	0.17		101.56	165.23	2.29
98	479.63	0.00	1.56	61.49	2.00	0.17		101.56	165.23	2.29
99	479.63	0.00	1.56	61.49	2.00	0.17		101.56	165.23	2.29
100	479.64	0.00	1.56	61.49	2.00	0.17		101.56	165.23	2.29
101	479.64	0.00	1.56	61.49	2.00	0.17		101.56	165.23	2.29
102	479.65	0.00	1.56	61.50	2.00	0.17		101.56	165.23	2.29
103	479.65	0.00	1.56	61.50	2.00	0.17		101.56	165.23	2.29

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (kg)	LW change (kg/day)	MS (kg/day)	Maintenance	Walking	LWG	Preg.	MS	Total	(kg/day)
104	479.65	0.00	1.56	61.50	2.00	0.17		101.56	165.23	2.29
105	479.66	0.00	1.56	61.50	2.00	0.17		101.56	165.23	2.29
106	479.66	0.00	1.56	61.50	2.00	0.17		101.56	165.23	2.29
107	479.67	0.00	1.50	61.50	2.00	0.17		97.36	161.03	2.23
108	479.68	0.01	1.50	61.50	2.00	0.47		97.36	161.33	2.23
109	479.69	0.01	1.50	61.50	2.00	0.47		97.36	161.33	2.23
110	479.70	0.01	1.50	61.50	2.00	0.47		97.36	161.34	2.23
111	479.71	0.01	1.50	61.50	2.00	0.47		97.36	161.34	2.23
112	479.73	0.01	1.50	61.50	2.00	0.47		97.36	161.34	2.23
113	479.74	0.01	1.50	61.50	2.00	0.47		97.36	161.34	2.23
114	479.75	0.01	1.50	61.51	2.00	0.47		97.36	161.34	2.23
115	479.76	0.01	1.50	61.51	2.00	0.47		97.36	161.34	2.23
116	479.77	0.01	1.50	61.51	2.00	0.47		97.36	161.34	2.23
117	479.79	0.01	1.50	61.51	2.00	0.47		97.36	161.34	2.23
118	479.80	0.01	1.50	61.51	2.00	0.47		97.36	161.35	2.23
119	479.81	0.01	1.50	61.51	2.00	0.47		97.36	161.35	2.23
120	479.82	0.01	1.50	61.51	2.00	0.47		97.36	161.35	2.23
121	479.83	0.01	1.50	61.51	2.00	0.47		97.36	161.35	2.23
122	479.84	0.01	1.50	61.51	2.00	0.47		97.36	161.35	2.23
123	479.86	0.01	1.50	61.52	2.00	0.47		97.36	161.35	2.23
124	479.87	0.01	1.43	61.52	2.00	0.47		93.01	157.00	2.17
125	479.90	0.03	1.43	61.52	2.00	1.10		93.01	157.63	2.17
126	479.92	0.03	1.43	61.52	2.00	1.10		93.01	157.64	2.17
127	479.95	0.03	1.43	61.52	2.00	1.10		93.01	157.64	2.17
128	479.98	0.03	1.43	61.53	2.00	1.10		93.01	157.64	2.17
129	480.01	0.03	1.43	61.53	2.00	1.10		93.01	157.64	2.17
130	480.03	0.03	1.43	61.53	2.00	1.10		93.01	157.65	2.17
131	480.06	0.03	1.43	61.54	2.00	1.10		93.01	157.65	2.17
132	480.09	0.03	1.43	61.54	2.00	1.10		93.01	157.65	2.17
133	480.12	0.03	1.43	61.54	2.00	1.10		93.01	157.65	2.17
134	480.14	0.03	1.43	61.54	2.00	1.10		93.01	157.66	2.17
135	480.17	0.03	1.43	61.55	2.00	1.10		93.01	157.66	2.17
136	480.20	0.03	1.43	61.55	2.00	1.10		93.01	157.66	2.17
137	480.23	0.03	1.43	61.55	2.00	1.10		93.01	157.66	2.17
138	480.25	0.03	1.36	61.55	2.00	1.10		88.62	153.27	2.10
139	480.29	0.04	1.36	61.56	2.00	1.55		88.62	153.73	2.10
140	480.33	0.04	1.36	61.56	2.00	1.55		88.62	153.73	2.10
141	480.37	0.04	1.36	61.56	2.00	1.55		88.62	153.74	2.10
142	480.41	0.04	1.36	61.57	2.00	1.55		88.62	153.74	2.10
143	480.45	0.04	1.36	61.57	2.00	1.55		88.62	153.74	2.10
144	480.49	0.04	1.36	61.58	2.00	1.55		88.62	153.75	2.10
145	480.53	0.04	1.36	61.58	2.00	1.55		88.62	153.75	2.10
146	480.56	0.04	1.36	61.58	2.00	1.55		88.62	153.75	2.10
147	480.60	0.04	1.36	61.59	2.00	1.55		88.62	153.76	2.10
148	480.64	0.04	1.36	61.59	2.00	1.55		88.62	153.76	2.10
149	480.68	0.04	1.36	61.59	2.00	1.55		88.62	153.77	2.10
150	480.72	0.04	1.36	61.60	2.00	1.55		88.62	153.77	2.10
151	480.76	0.04	1.36	61.60	2.00	1.55		88.62	153.77	2.10
152	480.80	0.04	1.36	61.61	2.00	1.55		88.62	153.78	2.10
153	480.84	0.04	1.36	61.61	2.00	1.55		88.62	153.78	2.10
154	480.87	0.04	1.30	61.61	2.00	1.55		84.25	149.42	2.04
155	480.94	0.07	1.30	61.62	2.00	2.61		84.25	150.49	2.04
156	481.01	0.07	1.30	61.63	2.00	2.61		84.25	150.49	2.04
157	481.07	0.07	1.30	61.63	2.00	2.61		84.25	150.50	2.04
158	481.14	0.07	1.30	61.64	2.00	2.61		84.25	150.50	2.04
159	481.20	0.07	1.30	61.64	2.00	2.61		84.25	150.51	2.04

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (kg)	LW change (kg/day)	MS (kg/day)	Maintenance	Walking	LWG	Preg.	MS	Total	(kg/day)
160	481.27	0.07	1.30	61.65	2.00	2.61		84.25	150.52	2.04
161	481.33	0.07	1.30	61.66	2.00	2.61		84.25	150.52	2.04
162	481.40	0.07	1.30	61.66	2.00	2.61		84.25	150.53	2.04
163	481.46	0.07	1.30	61.67	2.00	2.61		84.25	150.54	2.04
164	481.53	0.07	1.30	61.68	2.00	2.61		84.25	150.54	2.04
165	481.59	0.07	1.30	61.68	2.00	2.61		84.25	150.55	2.04
166	481.66	0.07	1.30	61.69	2.00	2.61		84.25	150.55	2.04
167	481.72	0.07	1.30	61.70	2.00	2.61		84.25	150.56	2.04
168	481.79	0.07	1.23	61.70	2.00	2.61		79.96	146.27	1.99
169	481.86	0.07	1.23	61.71	2.00	3.00		79.96	146.67	1.99
170	481.94	0.07	1.23	61.72	2.00	3.00		79.96	146.67	1.99
171	482.01	0.07	1.23	61.72	2.00	3.00		79.96	146.68	1.99
172	482.09	0.07	1.23	61.73	2.00	3.00		79.96	146.69	1.99
173	482.16	0.07	1.23	61.74	2.00	3.00		79.96	146.69	1.99
174	482.24	0.07	1.23	61.74	2.00	3.00		79.96	146.70	1.99
175	482.31	0.07	1.23	61.75	2.00	3.00		79.96	146.71	1.99
176	482.39	0.07	1.23	61.76	2.00	3.00		79.96	146.72	1.99
177	482.46	0.07	1.23	61.77	2.00	3.00		79.96	146.72	1.99
178	482.54	0.07	1.23	61.77	2.00	3.00		79.96	146.73	1.99
179	482.61	0.07	1.23	61.78	2.00	3.00		79.96	146.74	1.99
180	482.69	0.07	1.23	61.79	2.00	3.00		79.96	146.74	1.99
181	482.76	0.07	1.23	61.79	2.00	3.00		79.96	146.75	1.99
182	482.84	0.07	1.23	61.80	2.00	3.00		79.96	146.76	1.99
183	482.91	0.07	1.23	61.81	2.00	3.00		79.96	146.77	1.99
184	482.99	0.07	1.23	61.82	2.00	3.00		79.96	146.77	1.99
185	483.06	0.07	1.17	61.82	2.00	3.00		75.77	142.60	1.92
186	483.19	0.12	1.17	61.84	2.00	4.87		75.77	144.48	1.92
187	483.31	0.12	1.17	61.85	2.00	4.87		75.77	144.49	1.92
188	483.43	0.12	1.17	61.86	2.00	4.87		75.77	144.50	1.92
189	483.55	0.12	1.17	61.87	2.00	4.87		75.77	144.51	1.92
190	483.67	0.12	1.17	61.88	2.00	4.87		75.77	144.52	1.92
191	483.80	0.12	1.17	61.89	2.00	4.87		75.77	144.54	1.92
192	483.92	0.12	1.17	61.91	2.00	4.87		75.77	144.55	1.92
193	484.04	0.12	1.17	61.92	2.00	4.87		75.77	144.56	1.92
194	484.16	0.12	1.17	61.93	2.00	4.87		75.77	144.57	1.92
195	484.28	0.12	1.17	61.94	2.00	4.87		75.77	144.58	1.92
196	484.40	0.12	1.17	61.95	2.00	4.87		75.77	144.59	1.92
197	484.53	0.12	1.17	61.96	2.00	4.87		75.77	144.61	1.92
198	484.65	0.12	1.17	61.98	2.00	4.87		75.77	144.62	1.92
199	484.77	0.12	1.10	61.99	2.00	4.87		71.72	140.57	1.88
200	484.90	0.13	1.10	62.00	2.00	5.20		71.72	140.91	1.88
201	485.03	0.13	1.10	62.01	2.00	5.20		71.72	140.93	1.88
202	485.16	0.13	1.10	62.02	2.00	5.20		71.72	140.94	1.88
203	485.29	0.13	1.10	62.04	2.00	5.20		71.72	140.95	1.88
204	485.42	0.13	1.10	62.05	2.00	5.20		71.72	140.96	1.88
205	485.55	0.13	1.10	62.06	2.00	5.20		71.72	140.98	1.88
206	485.68	0.13	1.10	62.07	2.00	5.20		71.72	140.99	1.88
207	485.81	0.13	1.10	62.09	2.00	5.20		71.72	141.00	1.88
208	485.94	0.13	1.10	62.10	2.00	5.20		71.72	141.01	1.88
209	486.07	0.13	1.10	62.11	2.00	5.20		71.72	141.03	1.88
210	486.20	0.13	1.10	62.12	2.00	5.20		71.72	141.04	1.88
211	486.33	0.13	1.10	62.14	2.00	5.20		71.72	141.05	1.88
212	486.46	0.13	1.10	62.15	2.00	5.20		71.72	141.06	1.88
213	486.59	0.13	1.10	62.16	2.00	5.20		71.72	141.08	1.88
214	486.72	0.13	1.10	62.17	2.00	5.20		71.72	141.09	1.88
215	486.85	0.13	1.10	62.19	2.00	5.20		71.72	141.10	1.88

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	**LW (kg)**	**LW change (kg/day)**	**MS (kg/day)**	**Maintenance**	**Walking**	**LWG**	**Preg.**	**MS**	**Total**	**(kg/day)**
216	**486.98**	**0.13**	**1.04**	62.20	2.00	5.20		67.81	137.20	1.82
217	**487.18**	**0.20**	**1.04**	62.22	2.00	7.97		67.81	139.99	1.82
218	**487.38**	**0.20**	**1.04**	62.24	2.00	7.97		67.81	140.01	1.82
219	**487.58**	**0.20**	**1.04**	62.26	2.00	7.97		67.81	140.03	1.82
220	**487.77**	**0.20**	**1.04**	62.28	2.00	7.97		67.81	140.05	1.82
221	**487.97**	**0.20**	**1.04**	62.29	2.00	7.97		67.81	140.07	1.82
222	**488.17**	**0.20**	**1.04**	62.31	2.00	7.97		67.81	140.09	1.82
223	**488.37**	**0.20**	**1.04**	62.33	2.00	7.97		67.81	140.11	1.82
224	**488.57**	**0.20**	**1.04**	62.35	2.00	7.97		67.81	140.12	1.82
225	**488.77**	**0.20**	**1.04**	62.37	2.00	7.97		67.81	140.14	1.82
226	**488.97**	**0.20**	**1.04**	62.39	2.00	7.97		67.81	140.16	1.82
227	**489.17**	**0.20**	**1.04**	62.41	2.00	7.97		67.81	140.18	1.82
228	**489.37**	**0.20**	**1.04**	62.43	2.00	7.97		67.81	140.20	1.82
229	**489.57**	**0.20**	**1.04**	62.45	2.00	7.97		67.81	140.22	1.82
230	**489.77**	**0.20**	**0.99**	62.47	2.00	7.97		64.05	136.48	1.80
231	**490.01**	**0.25**	**0.99**	62.49	2.00	9.84		64.05	138.38	1.80
232	**490.26**	**0.25**	**0.99**	62.51	2.00	9.84		64.05	138.40	1.80
233	**490.50**	**0.25**	**0.99**	62.54	2.00	9.84		64.05	138.42	1.80
234	**490.75**	**0.25**	**0.99**	62.56	2.00	9.84		64.05	138.45	1.80
235	**491.00**	**0.25**	**0.99**	62.58	2.00	9.84	5.00	64.05	143.47	1.80
236	**491.24**	**0.25**	**0.99**	62.61	2.00	9.84	5.00	64.05	143.49	1.80
237	**491.49**	**0.25**	**0.99**	62.63	2.00	9.84	5.00	64.05	143.52	1.80
238	**491.73**	**0.25**	**0.99**	62.65	2.00	9.84	5.00	64.05	143.54	1.80
239	**491.98**	**0.25**	**0.99**	62.68	2.00	9.84	5.00	64.05	143.56	1.80
240	**492.22**	**0.25**	**0.99**	62.70	2.00	9.84	5.00	64.05	143.59	1.80
241	**492.47**	**0.25**	**0.99**	62.72	2.00	9.84	5.00	64.05	143.61	1.80
242	**492.72**	**0.25**	**0.99**	62.75	2.00	9.84	5.00	64.05	143.63	1.80
243	**492.96**	**0.25**	**0.99**	62.77	2.00	9.84	5.00	64.05	143.66	1.80
244	**493.21**	**0.25**	**0.93**	62.79	2.00	9.84	5.00	60.45	140.08	1.77
245	**493.51**	**0.30**	**0.93**	62.82	2.00	11.91	5.00	60.45	142.19	1.77
246	**493.80**	**0.30**	**0.93**	62.85	2.00	11.91	5.00	60.45	142.22	1.77
247	**494.10**	**0.30**	**0.93**	62.88	2.00	11.91	5.00	60.45	142.24	1.77
248	**494.40**	**0.30**	**0.93**	62.91	2.00	11.91	5.00	60.45	142.27	1.77
249	**494.70**	**0.30**	**0.93**	62.94	2.00	11.91	5.00	60.45	142.30	1.77
250	**494.99**	**0.30**	**0.93**	62.97	2.00	11.91	5.00	60.45	142.33	1.77
251	**495.29**	**0.30**	**0.93**	62.99	2.00	11.91	5.00	60.45	142.36	1.77
252	**495.59**	**0.30**	**0.93**	63.02	2.00	11.91	5.00	60.45	142.39	1.77
253	**495.89**	**0.30**	**0.93**	63.05	2.00	11.91	5.00	60.45	142.41	1.77
254	**496.19**	**0.30**	**0.93**	63.08	2.00	11.91	5.00	60.45	142.44	1.77
255	**496.48**	**0.30**	**0.93**	63.11	2.00	11.91	5.00	60.45	142.47	1.77
256	**496.78**	**0.30**	**0.93**	63.14	2.00	11.91	5.00	60.45	142.50	1.77
257	**497.08**	**0.30**	**0.93**	63.16	2.00	11.91	5.00	60.45	142.53	1.77
258	**497.38**	**0.30**	**0.88**	63.19	2.00	11.91	5.00	57.02	139.12	1.74
259	**497.85**	**0.47**	**0.88**	63.24	2.00	18.89	5.00	57.02	146.15	1.74
260	**498.32**	**0.47**	**0.88**	63.28	2.00	18.89	5.00	57.02	146.19	1.74
261	**498.79**	**0.47**	**0.88**	63.33	2.00	18.89	5.00	57.02	146.24	1.74
262	**499.27**	**0.47**	**0.88**	63.37	2.00	18.89	5.00	57.02	146.28	1.74
263	**499.74**	**0.47**	**0.88**	63.42	2.00	18.89	5.00	57.02	146.33	1.74
264	**500.21**	**0.47**	**0.88**	63.46	2.00	18.89	5.00	57.02	146.37	1.74
265	**500.68**	**0.47**	**0.88**	63.51	2.00	18.89	10.00	57.02	151.42	1.74
266	**501.15**	**0.47**	**0.88**	63.55	2.00	18.89	10.00	57.02	151.46	1.74
267	**501.63**	**0.47**	**0.88**	63.60	2.00	18.89	10.00	57.02	151.51	1.74
268	**502.10**	**0.47**	**0.88**	63.64	2.00	18.89	10.00	57.02	151.55	1.74
269	**502.57**	**0.47**	**0.88**	63.69	2.00	18.89	10.00	57.02	151.60	1.74
270	**503.04**	**0.47**	**0.88**	63.73	2.00	18.89	10.00	57.02	151.64	1.74
271	**503.52**	**0.47**	**0.88**	63.78	2.00	18.89	10.00	57.02	151.69	1.74

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (kg)	LW change (kg/day)	MS (kg/day)	Maintenance	Walking	LWG	Preg.	MS	Total	(kg/day)
272	503.99	0.47		58.50		21.72	10.00	0.00	90.23	1.00
273	504.46	0.47		58.54		21.72	10.00	0.00	90.27	1.00
274	504.93	0.47		58.59		21.72	10.00	0.00	90.31	1.00
275	505.40	0.47		58.63		21.72	10.00	0.00	90.35	1.00
276	506.11	0.71		58.69		32.60	10.00	0.00	101.28	1.00
277	506.82	0.71		58.75		32.60	10.00	0.00	101.35	1.00
278	507.53	0.71		58.81		32.60	10.00	0.00	101.41	1.00
279	508.24	0.71		58.87		32.60	10.00	0.00	101.47	1.00
280	508.95	0.71		58.93		32.60	10.00	0.00	101.53	1.00
281	509.66	0.71		59.00		32.60	10.00	0.00	101.59	1.00
282	510.36	0.71		59.06		32.60	10.00	0.00	101.65	1.00
283	511.07	0.71		59.12		32.60	10.00	0.00	101.71	1.00
284	511.78	0.71		59.18		32.60	10.00	0.00	101.78	1.00
285	512.49	0.71		59.24		32.60	10.00	0.00	101.84	1.00
286	513.20	0.71		59.30		32.60	10.00	0.00	101.90	1.00
287	513.91	0.71		59.36		32.60	10.00	0.00	101.96	1.00
288	514.62	0.71		59.43		32.60	10.00	0.00	102.02	1.00
289	515.33	0.71		59.49		32.60	10.00	0.00	102.08	1.00
290	516.00	0.68		59.55		31.11	10.00	0.00	100.66	1.00
291	516.68	0.68		59.60		31.11	10.00	0.00	100.71	1.00
292	517.35	0.68		59.66		31.11	10.00	0.00	100.77	1.00
293	518.03	0.68		59.72		31.11	10.00	0.00	100.83	1.00
294	518.71	0.68		59.78		31.11	10.00	0.00	100.89	1.00
295	519.38	0.68		59.84		31.11	20.00	0.00	110.95	1.00
296	520.06	0.68		59.90		31.11	20.00	0.00	111.01	1.00
297	520.74	0.68		59.96		31.11	20.00	0.00	111.06	1.00
298	521.41	0.68		60.01		31.11	20.00	0.00	111.12	1.00
299	522.09	0.68		60.07		31.11	20.00	0.00	111.18	1.00
300	522.76	0.68		60.13		31.11	20.00	0.00	111.24	1.00
301	523.44	0.68		60.19		31.11	20.00	0.00	111.30	1.00
302	524.12	0.68		60.25		31.11	20.00	0.00	111.36	1.00
303	524.79	0.68		60.31		31.11	20.00	0.00	111.41	1.00
304	525.47	0.68		60.36		31.11	20.00	0.00	111.47	1.00
305	526.15	0.68		60.42		31.11	20.00	0.00	111.53	1.00
306	526.99	0.84		60.49		38.64	20.00	0.00	119.13	1.00
307	527.83	0.84		60.57		38.64	20.00	0.00	119.20	1.00
308	528.67	0.84		60.64		38.64	20.00	0.00	119.28	1.00
309	529.51	0.84		60.71		38.64	20.00	0.00	119.35	1.00
310	530.35	0.84		60.78		38.64	20.00	0.00	119.42	1.00
311	531.19	0.84		60.86		38.64	20.00	0.00	119.49	1.00
312	532.03	0.84		60.93		38.64	20.00	0.00	119.56	1.00
313	532.87	0.84		61.00		38.64	20.00	0.00	119.64	1.00
314	533.71	0.84		61.07		38.64	20.00	0.00	119.71	1.00
315	534.55	0.84		61.14		38.64	20.00	0.00	119.78	1.00
316	535.39	0.84		61.22		38.64	20.00	0.00	119.85	1.00
317	536.23	0.84		61.29		38.64	20.00	0.00	119.93	1.00
318	537.07	0.84		61.36		38.64	20.00	0.00	120.00	1.00
319	537.91	0.84		61.43		38.64	20.00	0.00	120.07	1.00
320	538.65	0.75		61.50		34.43	20.00	0.00	115.92	1.00
321	539.40	0.75		61.56		34.43	20.00	0.00	115.99	1.00
322	540.15	0.75		61.62		34.43	20.00	0.00	116.05	1.00
323	540.90	0.75		61.69		34.43	20.00	0.00	116.12	1.00
324	541.65	0.75		61.75		34.43	20.00	0.00	116.18	1.00
325	542.40	0.75		61.82		34.43	30.00	0.00	126.24	1.00
326	543.14	0.75		61.88		34.43	30.00	0.00	126.31	1.00
327	543.89	0.75		61.94		34.43	30.00	0.00	126.37	1.00

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	**LW (kg)**	**LW change (kg/day)**	**MS (kg/day)**	**Maintenance**	**Walking**	**LWG**	**Preg.**	**MS**	**Total**	**(kg/day)**
328	**544.64**	**0.75**		62.01		34.43	30.00	0.00	126.44	1.00
329	**545.39**	**0.75**		62.07		34.43	30.00	0.00	126.50	1.00
330	**546.14**	**0.75**		62.14		34.43	30.00	0.00	126.56	1.00
331	**546.89**	**0.75**		62.20		34.43	30.00	0.00	126.63	1.00
332	**547.63**	**0.75**		62.26		34.43	30.00	0.00	126.69	1.00
333	**548.38**	**0.75**		62.33		34.43	30.00	0.00	126.76	1.00
334	**549.13**	**0.75**		62.39		34.43	30.00	0.00	126.82	1.00
335	**549.88**	**0.75**		62.45		34.43	30.00	0.00	126.88	1.00
336	**550.63**	**0.75**		62.52		34.43	30.00	0.00	126.95	1.00
337	**551.61**	**0.98**		62.60		45.02	30.00	0.00	137.62	1.00
338	**552.59**	**0.98**		62.68		45.02	30.00	0.00	137.70	1.00
339	**553.56**	**0.98**		62.77		45.02	30.00	0.00	137.78	1.00
340	**554.54**	**0.98**		62.85		45.02	30.00	0.00	137.87	1.00
341	**555.52**	**0.98**		62.93		45.02	30.00	0.00	137.95	1.00
342	**556.50**	**0.98**		63.02		45.02	30.00	0.00	138.03	1.00
343	**557.48**	**0.98**		63.10		45.02	30.00	0.00	138.12	1.00
344	**558.46**	**0.98**		63.18		45.02	30.00	0.00	138.20	1.00
345	**559.44**	**0.98**		63.27		45.02	30.00	0.00	138.28	1.00
346	**560.41**	**0.98**		63.35		45.02	30.00	0.00	138.37	1.00
347	**561.39**	**0.98**		63.43		45.02	30.00	0.00	138.45	1.00
348	**562.37**	**0.98**		63.52		45.02	30.00	0.00	138.53	1.00
349	**563.35**	**0.98**		63.60		45.02	30.00	0.00	138.61	1.00
350	**564.33**	**0.98**		63.68		45.02	30.00	0.00	138.70	1.00
351	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
352	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
353	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
354	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
355	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
356	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
357	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
358	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
359	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
360	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
361	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
362	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
363	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
364	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.00
365	**564.33**			63.68		0.00	30.00	0.00	93.68	1.00

A.6.2 Cow producing 400 Kg MS per lactation; lactation length: 300 days

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (Kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
1	496.38	-0.52	1.47	63.10	2.00	-15.52		95.49	145.07	2.37
2	495.86	-0.52	1.47	63.05	2.00	-15.52		95.49	145.02	2.37
3	495.34	-0.52	1.47	63.00	2.00	-15.52		95.49	144.97	2.37
4	494.83	-0.52	1.47	62.95	2.00	-15.52		95.49	144.92	2.37
5	494.31	-0.52	1.47	62.90	2.00	-15.52		95.49	144.87	2.37
6	493.79	-0.52	1.47	62.85	2.00	-15.52		95.49	144.82	2.37
7	493.28	-0.52	1.47	62.80	2.00	-15.52		95.49	144.78	2.37
8	492.76	-0.52	1.47	62.75	2.00	-15.52		95.49	144.73	2.37
9	492.24	-0.52	1.47	62.70	2.00	-15.52		95.49	144.68	2.37
10	491.72	-0.52	1.47	62.65	2.00	-15.52		95.49	144.63	2.37
11	491.21	-0.52	1.47	62.60	2.00	-15.52		95.49	144.58	2.37
12	490.69	-0.52	1.47	62.55	2.00	-15.52		95.49	144.53	2.37
13	490.17	-0.52	1.47	62.50	2.00	-15.52		95.49	144.48	2.37
14	489.65	-0.52	1.47	62.46	2.00	-15.52		95.49	144.43	2.37
15	489.14	-0.52	1.69	62.41	2.00	-15.52		110.07	158.96	2.60
16	488.71	-0.43	1.69	62.36	2.00	-12.78		110.07	161.66	2.60
17	488.28	-0.43	1.69	62.32	2.00	-12.78		110.07	161.61	2.60
18	487.86	-0.43	1.69	62.28	2.00	-12.78		110.07	161.57	2.60
19	487.43	-0.43	1.69	62.24	2.00	-12.78		110.07	161.53	2.60
20	487.01	-0.43	1.69	62.20	2.00	-12.78		110.07	161.49	2.60
21	486.58	-0.43	1.69	62.16	2.00	-12.78		110.07	161.45	2.60
22	486.15	-0.43	1.69	62.12	2.00	-12.78		110.07	161.41	2.60
23	485.73	-0.43	1.69	62.08	2.00	-12.78		110.07	161.37	2.60
24	485.30	-0.43	1.69	62.04	2.00	-12.78		110.07	161.33	2.60
25	484.88	-0.43	1.69	62.00	2.00	-12.78		110.07	161.29	2.60
26	484.45	-0.43	1.69	61.96	2.00	-12.78		110.07	161.25	2.60
27	484.02	-0.43	1.69	61.92	2.00	-12.78		110.07	161.21	2.60
28	483.60	-0.43	1.69	61.87	2.00	-12.78		110.07	161.17	2.60
29	483.17	-0.43	1.69	61.83	2.00	-12.78		110.07	161.12	2.60
30	482.75	-0.43	1.69	61.79	2.00	-12.78		110.07	161.08	2.60
31	482.32	-0.43	1.69	61.75	2.00	-12.78		110.07	161.04	2.60
32	481.89	-0.43	1.74	61.71	2.00	-12.78		113.27	164.21	2.64
33	481.75	-0.15	1.74	61.70	2.00	-4.48		113.27	172.49	2.64
34	481.60	-0.15	1.74	61.68	2.00	-4.48		113.27	172.47	2.64
35	481.45	-0.15	1.74	61.67	2.00	-4.48		113.27	172.46	2.64
36	481.30	-0.15	1.74	61.65	2.00	-4.48		113.27	172.45	2.64
37	481.15	-0.15	1.74	61.64	2.00	-4.48		113.27	172.43	2.64
38	481.00	-0.15	1.74	61.63	2.00	-4.48		113.27	172.42	2.64
39	480.85	-0.15	1.74	61.61	2.00	-4.48		113.27	172.40	2.64
40	480.70	-0.15	1.74	61.60	2.00	-4.48		113.27	172.39	2.64
41	480.55	-0.15	1.74	61.58	2.00	-4.48		113.27	172.37	2.64
42	480.40	-0.15	1.74	61.57	2.00	-4.48		113.27	172.36	2.64
43	480.25	-0.15	1.74	61.55	2.00	-4.48		113.27	172.35	2.64
44	480.10	-0.15	1.74	61.54	2.00	-4.48		113.27	172.33	2.64
45	479.95	-0.15	1.74	61.52	2.00	-4.48		113.27	172.32	2.64
46	479.80	-0.15	1.73	61.51	2.00	-4.48		112.72	171.74	2.64
47	479.79	-0.02	1.73	61.51	2.00	-0.47		112.72	175.75	2.64
48	479.77	-0.02	1.73	61.51	2.00	-0.47		112.72	175.75	2.64
49	479.76	-0.02	1.73	61.51	2.00	-0.47		112.72	175.75	2.64
50	479.74	-0.02	1.73	61.50	2.00	-0.47		112.72	175.75	2.64
51	479.72	-0.02	1.73	61.50	2.00	-0.47		112.72	175.75	2.64
52	479.71	-0.02	1.73	61.50	2.00	-0.47		112.72	175.75	2.64
53	479.69	-0.02	1.73	61.50	2.00	-0.47		112.72	175.74	2.64

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (Kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
54	479.68	-0.02	1.73	61.50	2.00	-0.47		112.72	175.74	2.64
55	479.66	-0.02	1.73	61.50	2.00	-0.47		112.72	175.74	2.64
56	479.65	-0.02	1.73	61.50	2.00	-0.47		112.72	175.74	2.64
57	479.63	-0.02	1.73	61.49	2.00	-0.47		112.72	175.74	2.64
58	479.61	-0.02	1.73	61.49	2.00	-0.47		112.72	175.74	2.64
59	479.60	-0.02	1.73	61.49	2.00	-0.47		112.72	175.74	2.64
60	479.58	-0.02	1.73	61.49	2.00	-0.47		112.72	175.73	2.64
61	479.57	-0.02	1.73	61.49	2.00	-0.47		112.72	175.73	2.64
62	479.55	-0.02	1.73	61.49	2.00	-0.47		112.72	175.73	2.64
63	479.54	-0.02	1.70	61.48	2.00	-0.47		110.33	173.35	2.60
64	479.54	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
65	479.55	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
66	479.56	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
67	479.57	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
68	479.58	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
69	479.59	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
70	479.59	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
71	479.60	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
72	479.61	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
73	479.62	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
74	479.63	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
75	479.63	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
76	479.64	0.01	1.70	61.49	2.00	0.33		110.33	174.15	2.60
77	479.65	0.01	1.65	61.50	2.00	0.33		106.95	170.77	2.54
78	479.65	-0.00	1.65	61.50	2.00	-0.08		106.95	170.36	2.54
79	479.65	-0.00	1.65	61.50	2.00	-0.08		106.95	170.36	2.54
80	479.64	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
81	479.64	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
82	479.64	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
83	479.63	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
84	479.63	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
85	479.63	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
86	479.63	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
87	479.62	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
88	479.62	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
89	479.62	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
90	479.62	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
91	479.61	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
92	479.61	-0.00	1.65	61.49	2.00	-0.08		106.95	170.36	2.54
93	479.61	-0.00	1.58	61.49	2.00	-0.08		103.00	166.41	2.48
94	479.61	0.00	1.58	61.49	2.00	0.17		103.00	166.66	2.48
95	479.62	0.00	1.58	61.49	2.00	0.17		103.00	166.67	2.48
96	479.62	0.00	1.58	61.49	2.00	0.17		103.00	166.67	2.48
97	479.62	0.00	1.58	61.49	2.00	0.17		103.00	166.67	2.48
98	479.63	0.00	1.58	61.49	2.00	0.17		103.00	166.67	2.48
99	479.63	0.00	1.58	61.49	2.00	0.17		103.00	166.67	2.48
100	479.64	0.00	1.58	61.49	2.00	0.17		103.00	166.67	2.48
101	479.64	0.00	1.58	61.49	2.00	0.17		103.00	166.67	2.48
102	479.65	0.00	1.58	61.50	2.00	0.17		103.00	166.67	2.48
103	479.65	0.00	1.58	61.50	2.00	0.17		103.00	166.67	2.48
104	479.65	0.00	1.58	61.50	2.00	0.17		103.00	166.67	2.48
105	479.66	0.00	1.58	61.50	2.00	0.17		103.00	166.67	2.48
106	479.66	0.00	1.58	61.50	2.00	0.17		103.00	166.67	2.48
107	479.67	0.00	1.52	61.50	2.00	0.17		98.74	162.41	2.41
108	479.68	0.01	1.52	61.50	2.00	0.47		98.74	162.71	2.41
109	479.69	0.01	1.52	61.50	2.00	0.47		98.74	162.71	2.41

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (Kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
110	479.70	0.01	1.52	61.50	2.00	0.47		98.74	162.71	2.41
111	479.71	0.01	1.52	61.50	2.00	0.47		98.74	162.71	2.41
112	479.73	0.01	1.52	61.50	2.00	0.47		98.74	162.72	2.41
113	479.74	0.01	1.52	61.50	2.00	0.47		98.74	162.72	2.41
114	479.75	0.01	1.52	61.51	2.00	0.47		98.74	162.72	2.41
115	479.76	0.01	1.52	61.51	2.00	0.47		98.74	162.72	2.41
116	479.77	0.01	1.52	61.51	2.00	0.47		98.74	162.72	2.41
117	479.79	0.01	1.52	61.51	2.00	0.47		98.74	162.72	2.41
118	479.80	0.01	1.52	61.51	2.00	0.47		98.74	162.72	2.41
119	479.81	0.01	1.52	61.51	2.00	0.47		98.74	162.72	2.41
120	479.82	0.01	1.52	61.51	2.00	0.47		98.74	162.72	2.41
121	479.83	0.01	1.52	61.51	2.00	0.47		98.74	162.73	2.41
122	479.84	0.01	1.52	61.51	2.00	0.47		98.74	162.73	2.41
123	479.86	0.01	1.52	61.52	2.00	0.47		98.74	162.73	2.41
124	479.87	0.01	1.45	61.52	2.00	0.47		94.33	158.32	2.34
125	479.90	0.03	1.45	61.52	2.00	1.10		94.33	158.95	2.34
126	479.92	0.03	1.45	61.52	2.00	1.10		94.33	158.95	2.34
127	479.95	0.03	1.45	61.52	2.00	1.10		94.33	158.95	2.34
128	479.98	0.03	1.45	61.53	2.00	1.10		94.33	158.96	2.34
129	480.01	0.03	1.45	61.53	2.00	1.10		94.33	158.96	2.34
130	480.03	0.03	1.45	61.53	2.00	1.10		94.33	158.96	2.34
131	480.06	0.03	1.45	61.54	2.00	1.10		94.33	158.96	2.34
132	480.09	0.03	1.45	61.54	2.00	1.10		94.33	158.97	2.34
133	480.12	0.03	1.45	61.54	2.00	1.10		94.33	158.97	2.34
134	480.14	0.03	1.45	61.54	2.00	1.10		94.33	158.97	2.34
135	480.17	0.03	1.45	61.55	2.00	1.10		94.33	158.97	2.34
136	480.20	0.03	1.45	61.55	2.00	1.10		94.33	158.98	2.34
137	480.23	0.03	1.45	61.55	2.00	1.10		94.33	158.98	2.34
138	480.25	0.03	1.38	61.55	2.00	1.10		89.87	154.53	2.27
139	480.29	0.04	1.38	61.56	2.00	1.55		89.87	154.98	2.27
140	480.33	0.04	1.38	61.56	2.00	1.55		89.87	154.99	2.27
141	480.37	0.04	1.38	61.56	2.00	1.55		89.87	154.99	2.27
142	480.41	0.04	1.38	61.57	2.00	1.55		89.87	154.99	2.27
143	480.45	0.04	1.38	61.57	2.00	1.55		89.87	155.00	2.27
144	480.49	0.04	1.38	61.58	2.00	1.55		89.87	155.00	2.27
145	480.53	0.04	1.38	61.58	2.00	1.55		89.87	155.00	2.27
146	480.56	0.04	1.38	61.58	2.00	1.55		89.87	155.01	2.27
147	480.60	0.04	1.38	61.59	2.00	1.55		89.87	155.01	2.27
148	480.64	0.04	1.38	61.59	2.00	1.55		89.87	155.01	2.27
149	480.68	0.04	1.38	61.59	2.00	1.55		89.87	155.02	2.27
150	480.72	0.04	1.38	61.60	2.00	1.55		89.87	155.02	2.27
151	480.76	0.04	1.38	61.60	2.00	1.55		89.87	155.03	2.27
152	480.80	0.04	1.38	61.61	2.00	1.55		89.87	155.03	2.27
153	480.84	0.04	1.38	61.61	2.00	1.55		89.87	155.03	2.27
154	480.87	0.04	1.31	61.61	2.00	1.55		85.44	150.61	2.21
155	480.94	0.07	1.31	61.62	2.00	2.61		85.44	151.68	2.21
156	481.01	0.07	1.31	61.63	2.00	2.61		85.44	151.68	2.21
157	481.07	0.07	1.31	61.63	2.00	2.61		85.44	151.69	2.21
158	481.14	0.07	1.31	61.64	2.00	2.61		85.44	151.70	2.21
159	481.20	0.07	1.31	61.64	2.00	2.61		85.44	151.70	2.21
160	481.27	0.07	1.31	61.65	2.00	2.61		85.44	151.71	2.21
161	481.33	0.07	1.31	61.66	2.00	2.61		85.44	151.71	2.21
162	481.40	0.07	1.31	61.66	2.00	2.61		85.44	151.72	2.21
163	481.46	0.07	1.31	61.67	2.00	2.61		85.44	151.73	2.21
164	481.53	0.07	1.31	61.68	2.00	2.61		85.44	151.73	2.21
165	481.59	0.07	1.31	61.68	2.00	2.61		85.44	151.74	2.21

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (Kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
222	**488.17**	**0.20**	**1.06**	62.31	2.00	7.97		68.77	141.05	1.96
223	**488.37**	**0.20**	**1.06**	62.33	2.00	7.97		68.77	141.06	1.96
224	**488.57**	**0.20**	**1.06**	62.35	2.00	7.97		68.77	141.08	1.96
225	**488.77**	**0.20**	**1.06**	62.37	2.00	7.97		68.77	141.10	1.96
226	**488.97**	**0.20**	**1.06**	62.39	2.00	7.97		68.77	141.12	1.96
227	**489.17**	**0.20**	**1.06**	62.41	2.00	7.97		68.77	141.14	1.96
228	**489.37**	**0.20**	**1.06**	62.43	2.00	7.97		68.77	141.16	1.96
229	**489.57**	**0.20**	**1.06**	62.45	2.00	7.97		68.77	141.18	1.96
230	**489.77**	**0.20**	**1.00**	62.47	2.00	7.97		64.96	137.39	1.94
231	**490.01**	**0.25**	**1.00**	62.49	2.00	9.84		64.96	139.28	1.94
232	**490.26**	**0.25**	**1.00**	62.51	2.00	9.84		64.96	139.30	1.94
233	**490.50**	**0.25**	**1.00**	62.54	2.00	9.84		64.96	139.33	1.94
234	**490.75**	**0.25**	**1.00**	62.56	2.00	9.84		64.96	139.35	1.94
235	**491.00**	**0.25**	**1.00**	62.58	2.00	9.84	5.00	64.96	144.38	1.94
236	**491.24**	**0.25**	**1.00**	62.61	2.00	9.84	5.00	64.96	144.40	1.94
237	**491.49**	**0.25**	**1.00**	62.63	2.00	9.84	5.00	64.96	144.42	1.94
238	**491.73**	**0.25**	**1.00**	62.65	2.00	9.84	5.00	64.96	144.45	1.94
239	**491.98**	**0.25**	**1.00**	62.68	2.00	9.84	5.00	64.96	144.47	1.94
240	**492.22**	**0.25**	**1.00**	62.70	2.00	9.84	5.00	64.96	144.49	1.94
241	**492.47**	**0.25**	**1.00**	62.72	2.00	9.84	5.00	64.96	144.52	1.94
242	**492.72**	**0.25**	**1.00**	62.75	2.00	9.84	5.00	64.96	144.54	1.94
243	**492.96**	**0.25**	**1.00**	62.77	2.00	9.84	5.00	64.96	144.56	1.94
244	**493.21**	**0.25**	**0.94**	62.79	2.00	9.84	5.00	61.31	140.94	1.91
245	**493.51**	**0.30**	**0.94**	62.82	2.00	11.91	5.00	61.31	143.04	1.91
246	**493.80**	**0.30**	**0.94**	62.85	2.00	11.91	5.00	61.31	143.07	1.91
247	**494.10**	**0.30**	**0.94**	62.88	2.00	11.91	5.00	61.31	143.10	1.91
248	**494.40**	**0.30**	**0.94**	62.91	2.00	11.91	5.00	61.31	143.13	1.91
249	**494.70**	**0.30**	**0.94**	62.94	2.00	11.91	5.00	61.31	143.16	1.91
250	**494.99**	**0.30**	**0.94**	62.97	2.00	11.91	5.00	61.31	143.18	1.91
251	**495.29**	**0.30**	**0.94**	62.99	2.00	11.91	5.00	61.31	143.21	1.91
252	**495.59**	**0.30**	**0.94**	63.02	2.00	11.91	5.00	61.31	143.24	1.91
253	**495.89**	**0.30**	**0.94**	63.05	2.00	11.91	5.00	61.31	143.27	1.91
254	**496.19**	**0.30**	**0.94**	63.08	2.00	11.91	5.00	61.31	143.30	1.91
255	**496.48**	**0.30**	**0.94**	63.11	2.00	11.91	5.00	61.31	143.33	1.91
256	**496.78**	**0.30**	**0.94**	63.14	2.00	11.91	5.00	61.31	143.35	1.91
257	**497.08**	**0.30**	**0.94**	63.16	2.00	11.91	5.00	61.31	143.38	1.91
258	**497.38**	**0.30**	**0.89**	63.19	2.00	11.91	5.00	57.83	139.93	1.88
259	**497.85**	**0.47**	**0.89**	63.24	2.00	18.89	5.00	57.83	146.95	1.88
260	**498.32**	**0.47**	**0.89**	63.28	2.00	18.89	5.00	57.83	147.00	1.88
261	**498.79**	**0.47**	**0.89**	63.33	2.00	18.89	5.00	57.83	147.04	1.88
262	**499.27**	**0.47**	**0.89**	63.37	2.00	18.89	5.00	57.83	147.09	1.88
263	**499.74**	**0.47**	**0.89**	63.42	2.00	18.89	5.00	57.83	147.13	1.88
264	**500.21**	**0.47**	**0.89**	63.46	2.00	18.89	5.00	57.83	147.18	1.88
265	**500.68**	**0.47**	**0.89**	63.51	2.00	18.89	10.00	57.83	152.22	1.88
266	**501.15**	**0.47**	**0.89**	63.55	2.00	18.89	10.00	57.83	152.27	1.88
267	**501.63**	**0.47**	**0.89**	63.60	2.00	18.89	10.00	57.83	152.31	1.88
268	**502.10**	**0.47**	**0.89**	63.64	2.00	18.89	10.00	57.83	152.36	1.88
269	**502.57**	**0.47**	**0.89**	63.69	2.00	18.89	10.00	57.83	152.40	1.88
270	**503.04**	**0.47**	**0.89**	63.73	2.00	18.89	10.00	57.83	152.45	1.88
271	**503.52**	**0.47**	**0.89**	63.78	2.00	18.89	10.00	57.83	152.49	1.88
272	**503.99**	**0.47**	**0.89**	58.50		21.72	10.00	57.83	148.05	1.08
273	**504.46**	**0.47**	**0.89**	58.54		21.72	10.00	57.83	148.09	1.08
274	**504.93**	**0.47**	**0.89**	58.59		21.72	10.00	57.83	148.13	1.08
275	**505.40**	**0.47**	**0.84**	58.63		21.72	10.00	54.60	144.95	1.08
276	**506.11**	**0.71**	**0.84**	58.69		32.60	10.00	54.60	155.88	1.08
277	**506.82**	**0.71**	**0.84**	58.75		32.60	10.00	54.60	155.95	1.08

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (Kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
166	481.66	0.07	1.31	61.69	2.00	2.61		85.44	151.75	2.21
167	481.72	0.07	1.31	61.70	2.00	2.61		85.44	151.75	2.21
168	481.79	0.07	1.25	61.70	2.00	2.61		81.09	147.40	2.15
169	481.86	0.07	1.25	61.71	2.00	3.00		81.09	147.80	2.15
170	481.94	0.07	1.25	61.72	2.00	3.00		81.09	147.80	2.15
171	482.01	0.07	1.25	61.72	2.00	3.00		81.09	147.81	2.15
172	482.09	0.07	1.25	61.73	2.00	3.00		81.09	147.82	2.15
173	482.16	0.07	1.25	61.74	2.00	3.00		81.09	147.83	2.15
174	482.24	0.07	1.25	61.74	2.00	3.00		81.09	147.83	2.15
175	482.31	0.07	1.25	61.75	2.00	3.00		81.09	147.84	2.15
176	482.39	0.07	1.25	61.76	2.00	3.00		81.09	147.85	2.15
177	482.46	0.07	1.25	61.77	2.00	3.00		81.09	147.85	2.15
178	482.54	0.07	1.25	61.77	2.00	3.00		81.09	147.86	2.15
179	482.61	0.07	1.25	61.78	2.00	3.00		81.09	147.87	2.15
180	482.69	0.07	1.25	61.79	2.00	3.00		81.09	147.88	2.15
181	482.76	0.07	1.25	61.79	2.00	3.00		81.09	147.88	2.15
182	482.84	0.07	1.25	61.80	2.00	3.00		81.09	147.89	2.15
183	482.91	0.07	1.25	61.81	2.00	3.00		81.09	147.90	2.15
184	482.99	0.07	1.25	61.82	2.00	3.00		81.09	147.90	2.15
185	483.06	0.07	1.18	61.82	2.00	3.00		76.84	143.67	2.08
186	483.19	0.12	1.18	61.84	2.00	4.87		76.84	145.55	2.08
187	483.31	0.12	1.18	61.85	2.00	4.87		76.84	145.56	2.08
188	483.43	0.12	1.18	61.86	2.00	4.87		76.84	145.57	2.08
189	483.55	0.12	1.18	61.87	2.00	4.87		76.84	145.58	2.08
190	483.67	0.12	1.18	61.88	2.00	4.87		76.84	145.60	2.08
191	483.80	0.12	1.18	61.89	2.00	4.87		76.84	145.61	2.08
192	483.92	0.12	1.18	61.91	2.00	4.87		76.84	145.62	2.08
193	484.04	0.12	1.18	61.92	2.00	4.87		76.84	145.63	2.08
194	484.16	0.12	1.18	61.93	2.00	4.87		76.84	145.64	2.08
195	484.28	0.12	1.18	61.94	2.00	4.87		76.84	145.65	2.08
196	484.40	0.12	1.18	61.95	2.00	4.87		76.84	145.67	2.08
197	484.53	0.12	1.18	61.96	2.00	4.87		76.84	145.68	2.08
198	484.65	0.12	1.18	61.98	2.00	4.87		76.84	145.69	2.08
199	484.77	0.12	1.12	61.99	2.00	4.87		72.73	141.59	2.03
200	484.90	0.13	1.12	62.00	2.00	5.20		72.73	141.93	2.03
201	485.03	0.13	1.12	62.01	2.00	5.20		72.73	141.94	2.03
202	485.16	0.13	1.12	62.02	2.00	5.20		72.73	141.95	2.03
203	485.29	0.13	1.12	62.04	2.00	5.20		72.73	141.97	2.03
204	485.42	0.13	1.12	62.05	2.00	5.20		72.73	141.98	2.03
205	485.55	0.13	1.12	62.06	2.00	5.20		72.73	141.99	2.03
206	485.68	0.13	1.12	62.07	2.00	5.20		72.73	142.00	2.03
207	485.81	0.13	1.12	62.09	2.00	5.20		72.73	142.01	2.03
208	485.94	0.13	1.12	62.10	2.00	5.20		72.73	142.03	2.03
209	486.07	0.13	1.12	62.11	2.00	5.20		72.73	142.04	2.03
210	486.20	0.13	1.12	62.12	2.00	5.20		72.73	142.05	2.03
211	486.33	0.13	1.12	62.14	2.00	5.20		72.73	142.06	2.03
212	486.46	0.13	1.12	62.15	2.00	5.20		72.73	142.08	2.03
213	486.59	0.13	1.12	62.16	2.00	5.20		72.73	142.09	2.03
214	486.72	0.13	1.12	62.17	2.00	5.20		72.73	142.10	2.03
215	486.85	0.13	1.12	62.19	2.00	5.20		72.73	142.11	2.03
216	486.98	0.13	1.06	62.20	2.00	5.20		68.77	138.16	1.96
217	487.18	0.20	1.06	62.22	2.00	7.97		68.77	140.95	1.96
218	487.38	0.20	1.06	62.24	2.00	7.97		68.77	140.97	1.96
219	487.58	0.20	1.06	62.26	2.00	7.97		68.77	140.99	1.96
220	487.77	0.20	1.06	62.28	2.00	7.97		68.77	141.01	1.96
221	487.97	0.20	1.06	62.29	2.00	7.97		68.77	141.03	1.96

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (Kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
278	507.53	0.71	0.84	58.81		32.60	10.00	54.60	156.01	1.08
279	508.24	0.71	0.84	58.87		32.60	10.00	54.60	156.07	1.08
280	508.95	0.71	0.84	58.93		32.60	10.00	54.60	156.13	1.08
281	509.66	0.71	0.84	59.00		32.60	10.00	54.60	156.19	1.08
282	510.36	0.71	0.84	59.06		32.60	10.00	54.60	156.25	1.08
283	511.07	0.71	0.84	59.12		32.60	10.00	54.60	156.31	1.08
284	511.78	0.71	0.84	59.18		32.60	10.00	54.60	156.38	1.08
285	512.49	0.71	0.84	59.24		32.60	10.00	54.60	156.44	1.08
286	513.20	0.71	0.84	59.30		32.60	10.00	54.60	156.50	1.08
287	513.91	0.71	0.84	59.36		32.60	10.00	54.60	156.56	1.08
288	514.62	0.71	0.84	59.43		32.60	10.00	54.60	156.62	1.08
289	515.33	0.71	0.79	59.49		32.60	10.00	51.35	153.43	1.08
290	516.00	0.68	0.79	59.55		31.11	10.00	51.35	152.01	1.08
291	516.68	0.68	0.79	59.60		31.11	10.00	51.35	152.06	1.08
292	517.35	0.68	0.79	59.66		31.11	10.00	51.35	152.12	1.08
293	518.03	0.68	0.79	59.72		31.11	10.00	51.35	152.18	1.08
294	518.71	0.68	0.79	59.78		31.11	10.00	51.35	152.24	1.08
295	519.38	0.68	0.79	59.84		31.11	20.00	51.35	162.30	1.08
296	520.06	0.68	0.79	59.90		31.11	20.00	51.35	162.36	1.08
297	520.74	0.68	0.79	59.96		31.11	20.00	51.35	162.41	1.08
298	521.41	0.68	0.79	60.01		31.11	20.00	51.35	162.47	1.08
299	522.09	0.68	0.79	60.07		31.11	20.00	51.35	162.53	1.08
300	522.76	0.68	0.79	60.13		31.11	20.00	51.35	162.59	1.08
301	523.44	0.68	0.79	60.19		31.11	20.00	51.35	162.65	1.08
302	524.12	0.68		60.25		31.11	20.00	0.00	111.36	1.08
303	524.79	0.68		60.31		31.11	20.00	0.00	111.41	1.08
304	525.47	0.68		60.36		31.11	20.00	0.00	111.47	1.08
305	526.15	0.68		60.42		31.11	20.00	0.00	111.53	1.08
306	526.99	0.84		60.49		38.64	20.00	0.00	119.13	1.08
307	527.83	0.84		60.57		38.64	20.00	0.00	119.20	1.08
308	528.67	0.84		60.64		38.64	20.00	0.00	119.28	1.08
309	529.51	0.84		60.71		38.64	20.00	0.00	119.35	1.08
310	530.35	0.84		60.78		38.64	20.00	0.00	119.42	1.08
311	531.19	0.84		60.86		38.64	20.00	0.00	119.49	1.08
312	532.03	0.84		60.93		38.64	20.00	0.00	119.56	1.08
313	532.87	0.84		61.00		38.64	20.00	0.00	119.64	1.08
314	533.71	0.84		61.07		38.64	20.00	0.00	119.71	1.08
315	534.55	0.84		61.14		38.64	20.00	0.00	119.78	1.08
316	535.39	0.84		61.22		38.64	20.00	0.00	119.85	1.08
317	536.23	0.84		61.29		38.64	20.00	0.00	119.93	1.08
318	537.07	0.84		61.36		38.64	20.00	0.00	120.00	1.08
319	537.91	0.84		61.43		38.64	20.00	0.00	120.07	1.08
320	538.65	0.75		61.50		34.43	20.00	0.00	115.92	1.08
321	539.40	0.75		61.56		34.43	20.00	0.00	115.99	1.08
322	540.15	0.75		61.62		34.43	20.00	0.00	116.05	1.08
323	540.90	0.75		61.69		34.43	20.00	0.00	116.12	1.08
324	541.65	0.75		61.75		34.43	20.00	0.00	116.18	1.08
325	542.40	0.75		61.82		34.43	30.00	0.00	126.24	1.08
326	543.14	0.75		61.88		34.43	30.00	0.00	126.31	1.08
327	543.89	0.75		61.94		34.43	30.00	0.00	126.37	1.08
328	544.64	0.75		62.01		34.43	30.00	0.00	126.44	1.08
329	545.39	0.75		62.07		34.43	30.00	0.00	126.50	1.08
330	546.14	0.75		62.14		34.43	30.00	0.00	126.56	1.08
331	546.89	0.75		62.20		34.43	30.00	0.00	126.63	1.08
332	547.63	0.75		62.26		34.43	30.00	0.00	126.69	1.08
333	548.38	0.75		62.33		34.43	30.00	0.00	126.76	1.08

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (Kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
334	549.13	0.75		62.39		34.43	30.00	0.00	126.82	1.08
335	549.88	0.75		62.45		34.43	30.00	0.00	126.88	1.08
336	550.63	0.75		62.52		34.43	30.00	0.00	126.95	1.08
337	551.61	0.98		62.60		45.02	30.00	0.00	137.62	1.08
338	552.59	0.98		62.68		45.02	30.00	0.00	137.70	1.08
339	553.56	0.98		62.77		45.02	30.00	0.00	137.78	1.08
340	554.54	0.98		62.85		45.02	30.00	0.00	137.87	1.08
341	555.52	0.98		62.93		45.02	30.00	0.00	137.95	1.08
342	556.50	0.98		63.02		45.02	30.00	0.00	138.03	1.08
343	557.48	0.98		63.10		45.02	30.00	0.00	138.12	1.08
344	558.46	0.98		63.18		45.02	30.00	0.00	138.20	1.08
345	559.44	0.98		63.27		45.02	30.00	0.00	138.28	1.08
346	560.41	0.98		63.35		45.02	30.00	0.00	138.37	1.08
347	561.39	0.98		63.43		45.02	30.00	0.00	138.45	1.08
348	562.37	0.98		63.52		45.02	30.00	0.00	138.53	1.08
349	563.35	0.98		63.60		45.02	30.00	0.00	138.61	1.08
350	564.33	0.98		63.68		45.02	30.00	0.00	138.70	1.08
351	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
352	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
353	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
354	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
355	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
356	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
357	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
358	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
359	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
360	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
361	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
362	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
363	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
364	564.33	0.00		63.68		0.00	30.00	0.00	93.68	1.08
365	564.33			63.68		0.00	30.00	0.00	93.68	1.08

A.6.3 Cow producing 430 Kg MS per lactation; lactation length: 300 days

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
1	496.38	-0.52	1.58	63.10	2.00	-15.52		102.65	152.23	2.54
2	495.86	-0.52	1.58	63.05	2.00	-15.52		102.65	152.18	2.54
3	495.34	-0.52	1.58	63.00	2.00	-15.52		102.65	152.13	2.54
4	494.83	-0.52	1.58	62.95	2.00	-15.52		102.65	152.09	2.54
5	494.31	-0.52	1.58	62.90	2.00	-15.52		102.65	152.04	2.54
6	493.79	-0.52	1.58	62.85	2.00	-15.52		102.65	151.99	2.54
7	493.28	-0.52	1.58	62.80	2.00	-15.52		102.65	151.94	2.54
8	492.76	-0.52	1.58	62.75	2.00	-15.52		102.65	151.89	2.54
9	492.24	-0.52	1.58	62.70	2.00	-15.52		102.65	151.84	2.54
10	491.72	-0.52	1.58	62.65	2.00	-15.52		102.65	151.79	2.54
11	491.21	-0.52	1.58	62.60	2.00	-15.52		102.65	151.74	2.54
12	490.69	-0.52	1.58	62.55	2.00	-15.52		102.65	151.69	2.54
13	490.17	-0.52	1.58	62.50	2.00	-15.52		102.65	151.64	2.54
14	489.65	-0.52	1.58	62.46	2.00	-15.52		102.65	151.59	2.54
15	489.14	-0.52	1.82	62.41	2.00	-15.52		118.33	167.21	2.79
16	488.71	-0.43	1.82	62.36	2.00	-12.78		118.33	169.91	2.79
17	488.28	-0.43	1.82	62.32	2.00	-12.78		118.33	169.87	2.79
18	487.86	-0.43	1.82	62.28	2.00	-12.78		118.33	169.83	2.79
19	487.43	-0.43	1.82	62.24	2.00	-12.78		118.33	169.79	2.79
20	487.01	-0.43	1.82	62.20	2.00	-12.78		118.33	169.75	2.79
21	486.58	-0.43	1.82	62.16	2.00	-12.78		118.33	169.71	2.79
22	486.15	-0.43	1.82	62.12	2.00	-12.78		118.33	169.67	2.79
23	485.73	-0.43	1.82	62.08	2.00	-12.78		118.33	169.63	2.79
24	485.30	-0.43	1.82	62.04	2.00	-12.78		118.33	169.58	2.79
25	484.88	-0.43	1.82	62.00	2.00	-12.78		118.33	169.54	2.79
26	484.45	-0.43	1.82	61.96	2.00	-12.78		118.33	169.50	2.79
27	484.02	-0.43	1.82	61.92	2.00	-12.78		118.33	169.46	2.79
28	483.60	-0.43	1.82	61.87	2.00	-12.78		118.33	169.42	2.79
29	483.17	-0.43	1.82	61.83	2.00	-12.78		118.33	169.38	2.79
30	482.75	-0.43	1.82	61.79	2.00	-12.78		118.33	169.34	2.79
31	482.32	-0.43	1.82	61.75	2.00	-12.78		118.33	169.30	2.79
32	481.89	-0.43	1.87	61.71	2.00	-12.78		121.77	172.70	2.84
33	481.75	-0.15	1.87	61.70	2.00	-4.48		121.77	180.98	2.84
34	481.60	-0.15	1.87	61.68	2.00	-4.48		121.77	180.97	2.84
35	481.45	-0.15	1.87	61.67	2.00	-4.48		121.77	180.96	2.84
36	481.30	-0.15	1.87	61.65	2.00	-4.48		121.77	180.94	2.84
37	481.15	-0.15	1.87	61.64	2.00	-4.48		121.77	180.93	2.84
38	481.00	-0.15	1.87	61.63	2.00	-4.48		121.77	180.91	2.84
39	480.85	-0.15	1.87	61.61	2.00	-4.48		121.77	180.90	2.84
40	480.70	-0.15	1.87	61.60	2.00	-4.48		121.77	180.88	2.84
41	480.55	-0.15	1.87	61.58	2.00	-4.48		121.77	180.87	2.84
42	480.40	-0.15	1.87	61.57	2.00	-4.48		121.77	180.86	2.84
43	480.25	-0.15	1.87	61.55	2.00	-4.48		121.77	180.84	2.84
44	480.10	-0.15	1.87	61.54	2.00	-4.48		121.77	180.83	2.84
45	479.95	-0.15	1.87	61.52	2.00	-4.48		121.77	180.81	2.84
46	479.80	-0.15	1.86	61.51	2.00	-4.48		121.17	180.20	2.83
47	479.79	-0.02	1.86	61.51	2.00	-0.47		121.17	184.21	2.83
48	479.77	-0.02	1.86	61.51	2.00	-0.47		121.17	184.21	2.83
49	479.76	-0.02	1.86	61.51	2.00	-0.47		121.17	184.20	2.83
50	479.74	-0.02	1.86	61.50	2.00	-0.47		121.17	184.20	2.83
51	479.72	-0.02	1.86	61.50	2.00	-0.47		121.17	184.20	2.83
52	479.71	-0.02	1.86	61.50	2.00	-0.47		121.17	184.20	2.83
53	479.69	-0.02	1.86	61.50	2.00	-0.47		121.17	184.20	2.83
54	479.68	-0.02	1.86	61.50	2.00	-0.47		121.17	184.20	2.83

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	**LW (Kg)**	**LW change (kg/day)**	**MS (kg/day)**	**Maint.**	**Walking**	**LWG**	**Preg.**	**MS**	**Total**	**(kg/day)**
55	**479.66**	**-0.02**	**1.86**	61.50	2.00	-0.47		121.17	184.20	2.83
56	**479.65**	**-0.02**	**1.86**	61.50	2.00	-0.47		121.17	184.19	2.83
57	**479.63**	**-0.02**	**1.86**	61.49	2.00	-0.47		121.17	184.19	2.83
58	**479.61**	**-0.02**	**1.86**	61.49	2.00	-0.47		121.17	184.19	2.83
59	**479.60**	**-0.02**	**1.86**	61.49	2.00	-0.47		121.17	184.19	2.83
60	**479.58**	**-0.02**	**1.86**	61.49	2.00	-0.47		121.17	184.19	2.83
61	**479.57**	**-0.02**	**1.86**	61.49	2.00	-0.47		121.17	184.19	2.83
62	**479.55**	**-0.02**	**1.86**	61.49	2.00	-0.47		121.17	184.18	2.83
63	**479.54**	**-0.02**	**1.82**	61.48	2.00	-0.47		118.61	181.62	2.79
64	**479.54**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.42	2.79
65	**479.55**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.42	2.79
66	**479.56**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.42	2.79
67	**479.57**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.42	2.79
68	**479.58**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.42	2.79
69	**479.59**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.42	2.79
70	**479.59**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.43	2.79
71	**479.60**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.43	2.79
72	**479.61**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.43	2.79
73	**479.62**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.43	2.79
74	**479.63**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.43	2.79
75	**479.63**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.43	2.79
76	**479.64**	**0.01**	**1.82**	61.49	2.00	0.33		118.61	182.43	2.79
77	**479.65**	**0.01**	**1.77**	61.50	2.00	0.33		114.97	178.79	2.73
78	**479.65**	**-0.00**	**1.77**	61.50	2.00	-0.08		114.97	178.38	2.73
79	**479.65**	**-0.00**	**1.77**	61.50	2.00	-0.08		114.97	178.38	2.73
80	**479.64**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
81	**479.64**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
82	**479.64**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
83	**479.63**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
84	**479.63**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
85	**479.63**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
86	**479.63**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
87	**479.62**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
88	**479.62**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
89	**479.62**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
90	**479.62**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
91	**479.61**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
92	**479.61**	**-0.00**	**1.77**	61.49	2.00	-0.08		114.97	178.38	2.73
93	**479.61**	**-0.00**	**1.70**	61.49	2.00	-0.08		110.73	174.13	2.66
94	**479.61**	**0.00**	**1.70**	61.49	2.00	0.17		110.73	174.39	2.66
95	**479.62**	**0.00**	**1.70**	61.49	2.00	0.17		110.73	174.39	2.66
96	**479.62**	**0.00**	**1.70**	61.49	2.00	0.17		110.73	174.39	2.66
97	**479.62**	**0.00**	**1.70**	61.49	2.00	0.17		110.73	174.39	2.66
98	**479.63**	**0.00**	**1.70**	61.49	2.00	0.17		110.73	174.39	2.66
99	**479.63**	**0.00**	**1.70**	61.49	2.00	0.17		110.73	174.39	2.66
100	**479.64**	**0.00**	**1.70**	61.49	2.00	0.17		110.73	174.39	2.66
101	**479.64**	**0.00**	**1.70**	61.49	2.00	0.17		110.73	174.39	2.66
102	**479.65**	**0.00**	**1.70**	61.50	2.00	0.17		110.73	174.39	2.66
103	**479.65**	**0.00**	**1.70**	61.50	2.00	0.17		110.73	174.39	2.66
104	**479.65**	**0.00**	**1.70**	61.50	2.00	0.17		110.73	174.39	2.66
105	**479.66**	**0.00**	**1.70**	61.50	2.00	0.17		110.73	174.39	2.66
106	**479.66**	**0.00**	**1.70**	61.50	2.00	0.17		110.73	174.39	2.66
107	**479.67**	**0.00**	**1.63**	61.50	2.00	0.17		106.14	169.82	2.59
108	**479.68**	**0.01**	**1.63**	61.50	2.00	0.47		106.14	170.12	2.59
109	**479.69**	**0.01**	**1.63**	61.50	2.00	0.47		106.14	170.12	2.59
110	**479.70**	**0.01**	**1.63**	61.50	2.00	0.47		106.14	170.12	2.59

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
111	479.71	0.01	1.63	61.50	2.00	0.47		106.14	170.12	2.59
112	479.73	0.01	1.63	61.50	2.00	0.47		106.14	170.12	2.59
113	479.74	0.01	1.63	61.50	2.00	0.47		106.14	170.12	2.59
114	479.75	0.01	1.63	61.51	2.00	0.47		106.14	170.12	2.59
115	479.76	0.01	1.63	61.51	2.00	0.47		106.14	170.12	2.59
116	479.77	0.01	1.63	61.51	2.00	0.47		106.14	170.13	2.59
117	479.79	0.01	1.63	61.51	2.00	0.47		106.14	170.13	2.59
118	479.80	0.01	1.63	61.51	2.00	0.47		106.14	170.13	2.59
119	479.81	0.01	1.63	61.51	2.00	0.47		106.14	170.13	2.59
120	479.82	0.01	1.63	61.51	2.00	0.47		106.14	170.13	2.59
121	479.83	0.01	1.63	61.51	2.00	0.47		106.14	170.13	2.59
122	479.84	0.01	1.63	61.51	2.00	0.47		106.14	170.13	2.59
123	479.86	0.01	1.63	61.52	2.00	0.47		106.14	170.13	2.59
124	479.87	0.01	1.56	61.52	2.00	0.47		101.40	165.39	2.51
125	479.90	0.03	1.56	61.52	2.00	1.10		101.40	166.02	2.51
126	479.92	0.03	1.56	61.52	2.00	1.10		101.40	166.03	2.51
127	479.95	0.03	1.56	61.52	2.00	1.10		101.40	166.03	2.51
128	479.98	0.03	1.56	61.53	2.00	1.10		101.40	166.03	2.51
129	480.01	0.03	1.56	61.53	2.00	1.10		101.40	166.03	2.51
130	480.03	0.03	1.56	61.53	2.00	1.10		101.40	166.04	2.51
131	480.06	0.03	1.56	61.54	2.00	1.10		101.40	166.04	2.51
132	480.09	0.03	1.56	61.54	2.00	1.10		101.40	166.04	2.51
133	480.12	0.03	1.56	61.54	2.00	1.10		101.40	166.04	2.51
134	480.14	0.03	1.56	61.54	2.00	1.10		101.40	166.05	2.51
135	480.17	0.03	1.56	61.55	2.00	1.10		101.40	166.05	2.51
136	480.20	0.03	1.56	61.55	2.00	1.10		101.40	166.05	2.51
137	480.23	0.03	1.56	61.55	2.00	1.10		101.40	166.05	2.51
138	480.25	0.03	1.49	61.55	2.00	1.10		96.61	161.27	2.44
139	480.29	0.04	1.49	61.56	2.00	1.55		96.61	161.72	2.44
140	480.33	0.04	1.49	61.56	2.00	1.55		96.61	161.73	2.44
141	480.37	0.04	1.49	61.56	2.00	1.55		96.61	161.73	2.44
142	480.41	0.04	1.49	61.57	2.00	1.55		96.61	161.73	2.44
143	480.45	0.04	1.49	61.57	2.00	1.55		96.61	161.74	2.44
144	480.49	0.04	1.49	61.58	2.00	1.55		96.61	161.74	2.44
145	480.53	0.04	1.49	61.58	2.00	1.55		96.61	161.74	2.44
146	480.56	0.04	1.49	61.58	2.00	1.55		96.61	161.75	2.44
147	480.60	0.04	1.49	61.59	2.00	1.55		96.61	161.75	2.44
148	480.64	0.04	1.49	61.59	2.00	1.55		96.61	161.76	2.44
149	480.68	0.04	1.49	61.59	2.00	1.55		96.61	161.76	2.44
150	480.72	0.04	1.49	61.60	2.00	1.55		96.61	161.76	2.44
151	480.76	0.04	1.49	61.60	2.00	1.55		96.61	161.77	2.44
152	480.80	0.04	1.49	61.61	2.00	1.55		96.61	161.77	2.44
153	480.84	0.04	1.49	61.61	2.00	1.55		96.61	161.77	2.44
154	480.87	0.04	1.41	61.61	2.00	1.55		91.85	157.02	2.37
155	480.94	0.07	1.41	61.62	2.00	2.61		91.85	158.08	2.37
156	481.01	0.07	1.41	61.63	2.00	2.61		91.85	158.09	2.37
157	481.07	0.07	1.41	61.63	2.00	2.61		91.85	158.10	2.37
158	481.14	0.07	1.41	61.64	2.00	2.61		91.85	158.10	2.37
159	481.20	0.07	1.41	61.64	2.00	2.61		91.85	158.11	2.37
160	481.27	0.07	1.41	61.65	2.00	2.61		91.85	158.12	2.37
161	481.33	0.07	1.41	61.66	2.00	2.61		91.85	158.12	2.37
162	481.40	0.07	1.41	61.66	2.00	2.61		91.85	158.13	2.37
163	481.46	0.07	1.41	61.67	2.00	2.61		91.85	158.14	2.37
164	481.53	0.07	1.41	61.68	2.00	2.61		91.85	158.14	2.37
165	481.59	0.07	1.41	61.68	2.00	2.61		91.85	158.15	2.37
166	481.66	0.07	1.41	61.69	2.00	2.61		91.85	158.15	2.37

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
167	481.72	0.07	1.41	61.70	2.00	2.61		91.85	158.16	2.37
168	481.79	0.07	1.34	61.70	2.00	2.61		87.17	153.49	2.30
169	481.86	0.07	1.34	61.71	2.00	3.00		87.17	153.88	2.30
170	481.94	0.07	1.34	61.72	2.00	3.00		87.17	153.89	2.30
171	482.01	0.07	1.34	61.72	2.00	3.00		87.17	153.89	2.30
172	482.09	0.07	1.34	61.73	2.00	3.00		87.17	153.90	2.30
173	482.16	0.07	1.34	61.74	2.00	3.00		87.17	153.91	2.30
174	482.24	0.07	1.34	61.74	2.00	3.00		87.17	153.91	2.30
175	482.31	0.07	1.34	61.75	2.00	3.00		87.17	153.92	2.30
176	482.39	0.07	1.34	61.76	2.00	3.00		87.17	153.93	2.30
177	482.46	0.07	1.34	61.77	2.00	3.00		87.17	153.94	2.30
178	482.54	0.07	1.34	61.77	2.00	3.00		87.17	153.94	2.30
179	482.61	0.07	1.34	61.78	2.00	3.00		87.17	153.95	2.30
180	482.69	0.07	1.34	61.79	2.00	3.00		87.17	153.96	2.30
181	482.76	0.07	1.34	61.79	2.00	3.00		87.17	153.96	2.30
182	482.84	0.07	1.34	61.80	2.00	3.00		87.17	153.97	2.30
183	482.91	0.07	1.34	61.81	2.00	3.00		87.17	153.98	2.30
184	482.99	0.07	1.34	61.82	2.00	3.00		87.17	153.99	2.30
185	483.06	0.07	1.27	61.82	2.00	3.00		82.61	149.43	2.23
186	483.19	0.12	1.27	61.84	2.00	4.87		82.61	151.31	2.23
187	483.31	0.12	1.27	61.85	2.00	4.87		82.61	151.32	2.23
188	483.43	0.12	1.27	61.86	2.00	4.87		82.61	151.34	2.23
189	483.55	0.12	1.27	61.87	2.00	4.87		82.61	151.35	2.23
190	483.67	0.12	1.27	61.88	2.00	4.87		82.61	151.36	2.23
191	483.80	0.12	1.27	61.89	2.00	4.87		82.61	151.37	2.23
192	483.92	0.12	1.27	61.91	2.00	4.87		82.61	151.38	2.23
193	484.04	0.12	1.27	61.92	2.00	4.87		82.61	151.39	2.23
194	484.16	0.12	1.27	61.93	2.00	4.87		82.61	151.41	2.23
195	484.28	0.12	1.27	61.94	2.00	4.87		82.61	151.42	2.23
196	484.40	0.12	1.27	61.95	2.00	4.87		82.61	151.43	2.23
197	484.53	0.12	1.27	61.96	2.00	4.87		82.61	151.44	2.23
198	484.65	0.12	1.27	61.98	2.00	4.87		82.61	151.45	2.23
199	484.77	0.12	1.20	61.99	2.00	4.87		78.19	147.04	2.18
200	484.90	0.13	1.20	62.00	2.00	5.20		78.19	147.38	2.18
201	485.03	0.13	1.20	62.01	2.00	5.20		78.19	147.40	2.18
202	485.16	0.13	1.20	62.02	2.00	5.20		78.19	147.41	2.18
203	485.29	0.13	1.20	62.04	2.00	5.20		78.19	147.42	2.18
204	485.42	0.13	1.20	62.05	2.00	5.20		78.19	147.43	2.18
205	485.55	0.13	1.20	62.06	2.00	5.20		78.19	147.44	2.18
206	485.68	0.13	1.20	62.07	2.00	5.20		78.19	147.46	2.18
207	485.81	0.13	1.20	62.09	2.00	5.20		78.19	147.47	2.18
208	485.94	0.13	1.20	62.10	2.00	5.20		78.19	147.48	2.18
209	486.07	0.13	1.20	62.11	2.00	5.20		78.19	147.49	2.18
210	486.20	0.13	1.20	62.12	2.00	5.20		78.19	147.51	2.18
211	486.33	0.13	1.20	62.14	2.00	5.20		78.19	147.52	2.18
212	486.46	0.13	1.20	62.15	2.00	5.20		78.19	147.53	2.18
213	486.59	0.13	1.20	62.16	2.00	5.20		78.19	147.54	2.18
214	486.72	0.13	1.20	62.17	2.00	5.20		78.19	147.56	2.18
215	486.85	0.13	1.20	62.19	2.00	5.20		78.19	147.57	2.18
216	486.98	0.13	1.14	62.20	2.00	5.20		73.92	143.32	2.11
217	487.18	0.20	1.14	62.22	2.00	7.97		73.92	146.11	2.11
218	487.38	0.20	1.14	62.24	2.00	7.97		73.92	146.13	2.11
219	487.58	0.20	1.14	62.26	2.00	7.97		73.92	146.15	2.11
220	487.77	0.20	1.14	62.28	2.00	7.97		73.92	146.16	2.11
221	487.97	0.20	1.14	62.29	2.00	7.97		73.92	146.18	2.11
222	488.17	0.20	1.14	62.31	2.00	7.97		73.92	146.20	2.11

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
223	488.37	0.20	1.14	62.33	2.00	7.97		73.92	146.22	2.11
224	488.57	0.20	1.14	62.35	2.00	7.97		73.92	146.24	2.11
225	488.77	0.20	1.14	62.37	2.00	7.97		73.92	146.26	2.11
226	488.97	0.20	1.14	62.39	2.00	7.97		73.92	146.28	2.11
227	489.17	0.20	1.14	62.41	2.00	7.97		73.92	146.30	2.11
228	489.37	0.20	1.14	62.43	2.00	7.97		73.92	146.32	2.11
229	489.57	0.20	1.14	62.45	2.00	7.97		73.92	146.34	2.11
230	489.77	0.20	1.07	62.47	2.00	7.97		69.83	142.26	2.08
231	490.01	0.25	1.07	62.49	2.00	9.84		69.83	144.15	2.08
232	490.26	0.25	1.07	62.51	2.00	9.84		69.83	144.18	2.08
233	490.50	0.25	1.07	62.54	2.00	9.84		69.83	144.20	2.08
234	490.75	0.25	1.07	62.56	2.00	9.84		69.83	144.22	2.08
235	491.00	0.25	1.07	62.58	2.00	9.84	5.00	69.83	149.25	2.08
236	491.24	0.25	1.07	62.61	2.00	9.84	5.00	69.83	149.27	2.08
237	491.49	0.25	1.07	62.63	2.00	9.84	5.00	69.83	149.29	2.08
238	491.73	0.25	1.07	62.65	2.00	9.84	5.00	69.83	149.32	2.08
239	491.98	0.25	1.07	62.68	2.00	9.84	5.00	69.83	149.34	2.08
240	492.22	0.25	1.07	62.70	2.00	9.84	5.00	69.83	149.36	2.08
241	492.47	0.25	1.07	62.72	2.00	9.84	5.00	69.83	149.39	2.08
242	492.72	0.25	1.07	62.75	2.00	9.84	5.00	69.83	149.41	2.08
243	492.96	0.25	1.07	62.77	2.00	9.84	5.00	69.83	149.43	2.08
244	493.21	0.25	1.01	62.79	2.00	9.84	5.00	65.91	145.54	2.05
245	493.51	0.30	1.01	62.82	2.00	11.91	5.00	65.91	147.64	2.05
246	493.80	0.30	1.01	62.85	2.00	11.91	5.00	65.91	147.67	2.05
247	494.10	0.30	1.01	62.88	2.00	11.91	5.00	65.91	147.70	2.05
248	494.40	0.30	1.01	62.91	2.00	11.91	5.00	65.91	147.73	2.05
249	494.70	0.30	1.01	62.94	2.00	11.91	5.00	65.91	147.75	2.05
250	494.99	0.30	1.01	62.97	2.00	11.91	5.00	65.91	147.78	2.05
251	495.29	0.30	1.01	62.99	2.00	11.91	5.00	65.91	147.81	2.05
252	495.59	0.30	1.01	63.02	2.00	11.91	5.00	65.91	147.84	2.05
253	495.89	0.30	1.01	63.05	2.00	11.91	5.00	65.91	147.87	2.05
254	496.19	0.30	1.01	63.08	2.00	11.91	5.00	65.91	147.90	2.05
255	496.48	0.30	1.01	63.11	2.00	11.91	5.00	65.91	147.92	2.05
256	496.78	0.30	1.01	63.14	2.00	11.91	5.00	65.91	147.95	2.05
257	497.08	0.30	1.01	63.16	2.00	11.91	5.00	65.91	147.98	2.05
258	497.38	0.30	0.96	63.19	2.00	11.91	5.00	62.16	144.26	2.02
259	497.85	0.47	0.96	63.24	2.00	18.89	5.00	62.16	151.29	2.02
260	498.32	0.47	0.96	63.28	2.00	18.89	5.00	62.16	151.33	2.02
261	498.79	0.47	0.96	63.33	2.00	18.89	5.00	62.16	151.38	2.02
262	499.27	0.47	0.96	63.37	2.00	18.89	5.00	62.16	151.42	2.02
263	499.74	0.47	0.96	63.42	2.00	18.89	5.00	62.16	151.47	2.02
264	500.21	0.47	0.96	63.46	2.00	18.89	5.00	62.16	151.51	2.02
265	500.68	0.47	0.96	63.51	2.00	18.89	10.00	62.16	156.56	2.02
266	501.15	0.47	0.96	63.55	2.00	18.89	10.00	62.16	156.60	2.02
267	501.63	0.47	0.96	63.60	2.00	18.89	10.00	62.16	156.65	2.02
268	502.10	0.47	0.96	63.64	2.00	18.89	10.00	62.16	156.69	2.02
269	502.57	0.47	0.96	63.69	2.00	18.89	10.00	62.16	156.74	2.02
270	503.04	0.47	0.96	63.73	2.00	18.89	10.00	62.16	156.78	2.02
271	503.52	0.47	0.96	63.78	2.00	18.89	10.00	62.16	156.83	2.02
272	503.99	0.47	0.96	58.50		21.72	10.00	62.16	152.39	1.16
273	504.46	0.47	0.96	58.54		21.72	10.00	62.16	152.43	1.16
274	504.93	0.47	0.96	58.59		21.72	10.00	62.16	152.47	1.16
275	505.40	0.47	0.90	58.63		21.72	10.00	58.59	148.94	1.16
276	506.11	0.71	0.90	58.69		32.60	10.00	58.59	159.88	1.16
277	506.82	0.71	0.90	58.75		32.60	10.00	58.59	159.94	1.16
278	507.53	0.71	0.90	58.81		32.60	10.00	58.59	160.00	1.16

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	LW (Kg)	LW change (kg/day)	MS (kg/day)	Maint.	Walking	LWG	Preg.	MS	Total	(kg/day)
279	508.24	0.71	0.90	58.87		32.60	10.00	58.59	160.06	1.16
280	508.95	0.71	0.90	58.93		32.60	10.00	58.59	160.12	1.16
281	509.66	0.71	0.90	59.00		32.60	10.00	58.59	160.19	1.16
282	510.36	0.71	0.90	59.06		32.60	10.00	58.59	160.25	1.16
283	511.07	0.71	0.90	59.12		32.60	10.00	58.59	160.31	1.16
284	511.78	0.71	0.90	59.18		32.60	10.00	58.59	160.37	1.16
285	512.49	0.71	0.90	59.24		32.60	10.00	58.59	160.43	1.16
286	513.20	0.71	0.90	59.30		32.60	10.00	58.59	160.49	1.16
287	513.91	0.71	0.90	59.36		32.60	10.00	58.59	160.55	1.16
288	514.62	0.71	0.90	59.43		32.60	10.00	58.59	160.62	1.16
289	515.33	0.71	0.85	59.49		32.60	10.00	55.20	157.28	1.16
290	516.00	0.68	0.85	59.55		31.11	10.00	55.20	155.85	1.16
291	516.68	0.68	0.85	59.60		31.11	10.00	55.20	155.91	1.16
292	517.35	0.68	0.85	59.66		31.11	10.00	55.20	155.97	1.16
293	518.03	0.68	0.85	59.72		31.11	10.00	55.20	156.03	1.16
294	518.71	0.68	0.85	59.78		31.11	10.00	55.20	156.09	1.16
295	519.38	0.68	0.85	59.84		31.11	20.00	55.20	166.15	1.16
296	520.06	0.68	0.85	59.90		31.11	20.00	55.20	166.20	1.16
297	520.74	0.68	0.85	59.96		31.11	20.00	55.20	166.26	1.16
298	521.41	0.68	0.85	60.01		31.11	20.00	55.20	166.32	1.16
299	522.09	0.68	0.85	60.07		31.11	20.00	55.20	166.38	1.16
300	522.76	0.68	0.85	60.13		31.11	20.00	55.20	166.44	1.16
301	523.44	0.68	0.85	60.19		31.11	20.00	55.20	166.50	1.16
302	524.12	0.68		60.25		31.11	20.00	0.00	111.36	1.16
303	524.79	0.68		60.31		31.11	20.00	0.00	111.41	1.16
304	525.47	0.68		60.36		31.11	20.00	0.00	111.47	1.16
305	526.15	0.68		60.42		31.11	20.00	0.00	111.53	1.16
306	526.99	0.84		60.49		38.64	20.00	0.00	119.13	1.16
307	527.83	0.84		60.57		38.64	20.00	0.00	119.20	1.16
308	528.67	0.84		60.64		38.64	20.00	0.00	119.28	1.16
309	529.51	0.84		60.71		38.64	20.00	0.00	119.35	1.16
310	530.35	0.84		60.78		38.64	20.00	0.00	119.42	1.16
311	531.19	0.84		60.86		38.64	20.00	0.00	119.49	1.16
312	532.03	0.84		60.93		38.64	20.00	0.00	119.56	1.16
313	532.87	0.84		61.00		38.64	20.00	0.00	119.64	1.16
314	533.71	0.84		61.07		38.64	20.00	0.00	119.71	1.16
315	534.55	0.84		61.14		38.64	20.00	0.00	119.78	1.16
316	535.39	0.84		61.22		38.64	20.00	0.00	119.85	1.16
317	536.23	0.84		61.29		38.64	20.00	0.00	119.93	1.16
318	537.07	0.84		61.36		38.64	20.00	0.00	120.00	1.16
319	537.91	0.84		61.43		38.64	20.00	0.00	120.07	1.16
320	538.65	0.75		61.50		34.43	20.00	0.00	115.92	1.16
321	539.40	0.75		61.56		34.43	20.00	0.00	115.99	1.16
322	540.15	0.75		61.62		34.43	20.00	0.00	116.05	1.16
323	540.90	0.75		61.69		34.43	20.00	0.00	116.12	1.16
324	541.65	0.75		61.75		34.43	20.00	0.00	116.18	1.16
325	542.40	0.75		61.82		34.43	30.00	0.00	126.24	1.16
326	543.14	0.75		61.88		34.43	30.00	0.00	126.31	1.16
327	543.89	0.75		61.94		34.43	30.00	0.00	126.37	1.16
328	544.64	0.75		62.01		34.43	30.00	0.00	126.44	1.16
329	545.39	0.75		62.07		34.43	30.00	0.00	126.50	1.16
330	546.14	0.75		62.14		34.43	30.00	0.00	126.56	1.16
331	546.89	0.75		62.20		34.43	30.00	0.00	126.63	1.16
332	547.63	0.75		62.26		34.43	30.00	0.00	126.69	1.16
333	548.38	0.75		62.33		34.43	30.00	0.00	126.76	1.16
334	549.13	0.75		62.39		34.43	30.00	0.00	126.82	1.16

				ME REQUIREMENTS (MJ)						CP REQ.
Days after calving	**LW (Kg)**	**LW change (kg/day)**	**MS (kg/day)**	**Maint.**	**Walking**	**LWG**	**Preg.**	**MS**	**Total**	**(kg/day)**
335	**549.88**	**0.75**		62.45		34.43	30.00	0.00	126.88	1.16
336	**550.63**	**0.75**		62.52		34.43	30.00	0.00	126.95	1.16
337	**551.61**	**0.98**		62.60		45.02	30.00	0.00	137.62	1.16
338	**552.59**	**0.98**		62.68		45.02	30.00	0.00	137.70	1.16
339	**553.56**	**0.98**		62.77		45.02	30.00	0.00	137.78	1.16
340	**554.54**	**0.98**		62.85		45.02	30.00	0.00	137.87	1.16
341	**555.52**	**0.98**		62.93		45.02	30.00	0.00	137.95	1.16
342	**556.50**	**0.98**		63.02		45.02	30.00	0.00	138.03	1.16
343	**557.48**	**0.98**		63.10		45.02	30.00	0.00	138.12	1.16
344	**558.46**	**0.98**		63.18		45.02	30.00	0.00	138.20	1.16
345	**559.44**	**0.98**		63.27		45.02	30.00	0.00	138.28	1.16
346	**560.41**	**0.98**		63.35		45.02	30.00	0.00	138.37	1.16
347	**561.39**	**0.98**		63.43		45.02	30.00	0.00	138.45	1.16
348	**562.37**	**0.98**		63.52		45.02	30.00	0.00	138.53	1.16
349	**563.35**	**0.98**		63.60		45.02	30.00	0.00	138.61	1.16
350	**564.33**	**0.98**		63.68		45.02	30.00	0.00	138.70	1.16
351	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
352	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
353	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
354	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
355	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
356	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
357	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
358	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
359	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
360	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
361	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
362	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
363	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
364	**564.33**	**0.00**		63.68		0.00	30.00	0.00	93.68	1.16
365	**564.33**			63.68		0.00	30.00	0.00	93.68	1.16

APPENDIX B

Physical Data: Feed Sources

B.1 Pasture

Table B.1 shows the pasture growth rates used in the model. These figures were provided by the case study farmer, and correspond to irrigated pasture, excluding N-boosted growth.

Table B.1 Pasture Growth Rates used in the Model

Month	Kg DM/ha/day
July	7
August	15
September	25
October	40
November	50
December	50
January	48
February	45
March	41
April	30
May	20
June	5

Source: Case study farm records

Figure B.1 shows the pasture growth rates and quality assumptions used in the model. Pasture growth rates were sourced from the case study farm records, whereas pasture quality assumptions were derived from Moller et al (1996).

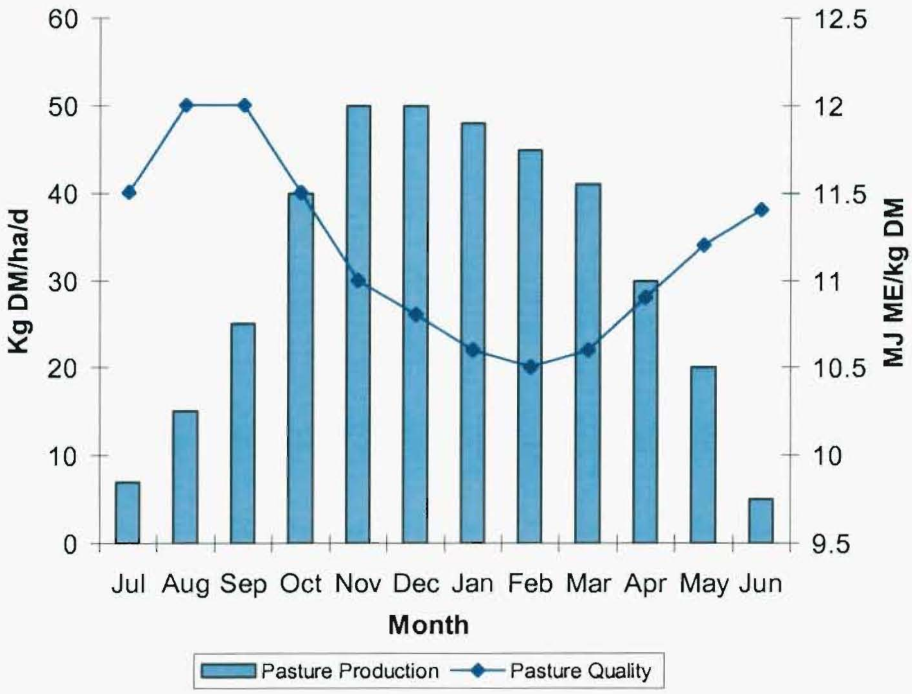


Figure B.1: Assumed Pasture Production and Quality (irrigated, without N)

Pasture production and quality data were aggregated into fortnightly periods, as shown in table B.2.

Table B.2 Pasture Production and Quality Data per Fortnightly Period

Sub period	Starting on	Kg DM/ha	MJ ME/kg DM
1	01-Jul	98	11.50
2	15-Jul	98	11.50
3	29-Jul	186	11.50
4	12-Aug	210	11.40
5	26-Aug	290	12.00
6	09-Sep	350	12.00
7	23-Sep	440	12.00
8	07-Oct	560	11.50
9	21-Oct	590	11.20
10	04-Nov	700	11.00
11	18-Nov	700	11.00
12	02-Dec	700	10.80
13	16-Dec	700	10.80
14	30-Dec	676	10.80
15	13-Jan	672	10.60
16	27-Jan	645	10.60
17	10-Feb	630	10.50
18	24-Feb	553	10.50
19	09-Mar	574	10.60
20	23-Mar	519	10.60
21	06-Apr	420	10.90
22	20-Apr	390	10.90
23	04-May	280	11.20
24	18-May	280	11.20
25	01-Jun	70	11.40
26	15-Jun	80	11.40

Sources: Case study farm records and Moller et al (1996).

B.2 Supplements

B.2.1 Nutritional value

Table B.3 shows the ME and CP values assumed for the supplements included in the model (Hughes, pers. comm.; Whatman[6], pers. comm.; Allison, 1999). These figures are averages, since the sources consulted reported wide ranges of nutritional compositions.

Table B.3 ME and CP values assumed for supplements

Supplement	MJ ME/kg DM	Kg CP/kg DM
Pasture silage	10.5	0.160
Barley grain	12.5	0.100
Whole crop cereal silage	9.5	0.120

Sources: Hughes (pers. comm.); Whitman (pers. comm.); Allison (1999).

B.2.2 Losses associated with supplementary feeding

Losses occur during storage (particularly with silage) and when the supplement is fed out. Silage losses of 5% to 50% could occur between storage and feeding out, depending on whether pit silage or bales are used (Whitman, pers. comm.). The figures used in the model for silage (both pasture and whole cereal crop silages) assume that bales are used for storage, and troughs for feeding out. Barely grain is assumed to be fed in the dairy shed.

Table B.4 shows the losses assumed for the supplements included in the model.

Table B.4 Assumed losses associated with feeding supplements

Supplement	Assumed losses (%) at storage and feeding out
Bought in silage	20
Barley grain	5
Whole crop silage	20
Silage making on farm	25

Sources: Whatman (pers. comm.); Allison (1999).

[6] Mr Tony Whatman is Director of Lincoln University Farms.

APPENDIX C

Economic Data: Calculation of the Objective Function Coefficients

C.1 Cow Activities

C.1.1 Seasonal Calving Cow with Lactation Length of 270 days

Table C.1 shows a summary of the calculation of the gross margin per cow, excluding income from milk sales, feed costs, and the cost of grazing off during the dry period. Table C.2 shows the detailed calculation of the cost of grazing off replacements, whereas table C.3 shows the assumed calf rearing costs.

Table C.1: Calculation of the Gross Margin of a cow calving in the spring period, with lactation length of 270 days

	Detail	Notes	$
Revenue per Cow			
Cull cows sales	$0.19 \times \$500$	1	95
Calves sales	$0.68 \times \$90$	2	61
Variable Expenses per Cow			
Animal health			(68)
Artificial breeding			(33)
Herd testing and recording			(5.2)
Minda			(0.2)
Electricity – Shed			(47)
Shed expenses			(23)
Grazing off replacements		Table C.2	(116)
Calf rearing costs	$0.22 \times \$159$	Table C.3	(35)
Direct labour		3	(235)
Interest	$\$1,400 \times 7.5\ \%$		(105)
Gross Margin per Cow			**($ 511)**

Sources: Case study farm records; Dairy Monitoring Report (2002); Lincoln University Financial Budget Manual (2002).

Notes:

1. Revenue derived from cull cows is calculated at the assumed replacement rate of 20%, less an allowance for death of 1%.
2. The assumption is that dairy cows on average produce 90% live calves. Given the replacement rate of 20%, and assuming a death rate of 10% of replacement heifers, 0.22 heifers calves are required per cow (0.20 / 0.90 ≅ 0.22). Thus, each cow yields 0.68 of a calf for sale, which is sold at 4 days of age (0.90 – 0.22 = 0.68).
3. Based on the assumption that 1 labour unit can handle 135 cows (Bayly and Hoogeven, 2002).

Table C.2: Per-cow cost of grazing off replacements

	Weeks	$/Week	Proportion of 1 cow	Totals ($)
IC heifers	8	15	0.20	24
R1Y heifers	52	6.5	0.21	71
Calves	24	4	0.22	21
Total per cow				**$ 116**

Lincoln University Financial Budget Manual (2002).

The cost of grazing off a cow during the dry period depends on the lactation length. Thus, a cow with a lactation length of 270 days has a dry period of approximately 12 weeks. Assuming a weekly rate of $15 per cow per week (Lincoln University Financial Budget Manual; 2002), the total cost of grazing off is $180 per cow. On the other hand, a cow with a lactation length of 300 days has a dry period of 8 weeks, which gives a grazing off cost of $120 per cow. .

Figure C.1 shows the timing of grazing-off, which was used to calculate the cost of grazing off both replacements and dry cows.

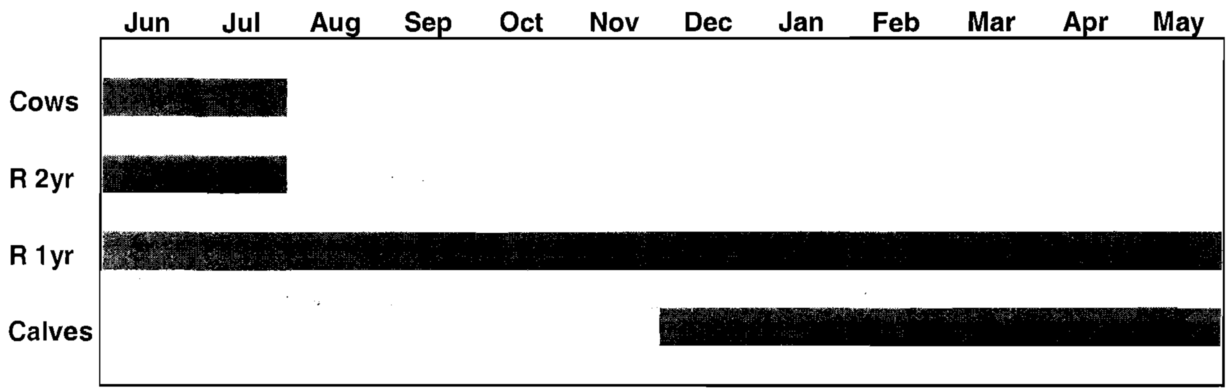


Figure C.1: Timing of grazing off

Table C.3: Calf rearing costs

	Price ($/kg)	Kg fed	$/head
CMR	3.50	19.1	66.9
Meal (20%)	0.76	21.5	16.4
Meal (16%)	0.71	52.5	37.3
Animal health			5
Bedding			3
Housing			10
Straw			2
Power			2.5
Interest			6
Tags (as per AHB)			1.55
Lossess (3%)			8.1
Total rearing costs		**$**	**159**

Source: Powkawa Project Newsletter (June 2002)

C.1.2 Out of Season Calving Cow with Lactation Length of 270 days

Cows calving outside the spring period would be in lactation during winter. It was assumed that such cows would incur extra costs associated with electricity, shed, and labour. These extra production costs were estimated with data provided by a factory supply dairy farmer who is also producing winter milk. Thus, both labour and shed costs were assumed to be 20% higher, and labour costs 23% higher than in a situation where the cow would not be in lactation during winter, as shown in Table C.4.

Table C.4: Calculation of the Gross Margin of a cow calving outside the spring period, with lactation length of 270 days

	Detail	Note	$
Revenue per Cow			
Cull cows sales	$0.19 \times \$500$		95
Calves sales	$0.68 \times \$90$		61
Variable Expenses per Cow			
Animal health			(68)
Artificial breeding			(33)
Herd testing and recording			(5.2)
Minda			(0.2)
Electricity – Shed			(56)
Shed expenses			(28)
Grazing off replacements			(116)
Calf rearing costs	$0.22 \times \$159$		(35)
Direct labour			(287)
Interest	$\$1,400 \times 7.5\ \%$		(105)
Feeding pad and feeding wagon annualised cost		Table C.5	(36)
Gross Margin per Cow			**($ 613)**

Sources: Case study farm records; Dairy Monitoring Report (2002); Lincoln University Financial Budget Manual (2002).

According to data provided by the dairy farmer referred to above, the capital outlay of having an appropriate feeding pad and feeding wagon would be $250 per cow. The calculation of the annualised cost of having such assets is presented in Table C.5

Table C.5: Calculation of the total annualised cost of a feeding pad and a feeding wagon

Capital cost	$	250.00
Interest rate		7.5%
Useful life		10
Annualized cost		**-36**[7]

[7] Annuity of a Present Value ($250 in this case)

C.1.3 Spring Calving Cow with Lactation Length of 300 days

The calculation of the gross margin of a spring calving cow with a lactation length of 300 days is presented in Table C.6. Due to a longer lactation, the costs related to electricity, shed, and labour are assumed higher than in a situation with a lactation length of 270 days. The other parameters are assumed the same as the ones assumed for a spring calving cow with a lactation length of 270 days (Table C1).

Table C.6: Calculation of the Gross Margin of a cow with lactation length of 300 days

	Detail	$
Revenue per Cow		
Cull cows sales	0.19 × $500	95
Calves sales	0.68 × $90	61
Variable Expenses per Cow		
Animal health		(68)
Artificial breeding		(33)
Herd testing and recording		(5.2)
Minda		(0.2)
Electricity – Shed		(52)
Shed expenses		(25)
Grazing off replacements		(116)
Calf rearing costs	0.22 × $159	(35)
Direct labour		(254)
Interest	$1,400 × 7.5 %	(105)
Gross Margin per Cow		**($ 537)**

Sources: Case study farm records; Dairy Monitoring Report (2002); Lincoln University Financial Budget Manual (2002).

C.1.4 Out of Season Calving Cow with Lactation Length of 300 days

As before, it was assumed that cows in lactation during winter would incur extra costs associated with electricity, shed, and labour. Thus, both labour and shed costs were assumed to be 20% higher, and labour costs 23% higher than in a situation where the cow would not be in lactation during winter, as presented in Table C.7.

Table C.7: Calculation of the Gross Margin of a cow calving outside the spring month, with lactation length of 300 days

	Detail	$
Revenue per Cow		
Cull cows sales	0.19 × $500	95
Calves sales	0.68 × $90	61
Variable Expenses per Cow		
Animal health		(68)
Artificial breeding		(33)
Herd testing and recording		(5.2)
Minda		(0.2)
Electricity – Shed		(62)
Shed expenses		(30)
Grazing off replacements		(116)
Calf rearing costs	0.22 × $159	(35)
Direct labour		(305)
Interest	$1,400 × 7.5 %	(105)
Feeding pad and feeding wagon annualised cost		(36)
Gross Margin per Cow		**($ 639)**

Sources: Case study farm records; Dairy Monitoring Report (2002); Lincoln University Financial Budget Manual (2002).

C.2 Pasture Production (Cost per hectare)

Table C.8: Pasture production cost

Item	$/ha
Fertiliser (excluding urea)	230
Spreading	18
Cartage	17
Weed and pest	7
Seeds	2
Soil testing	6
Total	**$ 280**

Source: Dairy Monitoring Report, 2002; Hockings, 2002

C.3 Supplements

Table C.5 Assumed supplement prices

Supplement	Cost
Bought in silage	$ 0.22 / kg DM
Barley grain	$ 0.33 / kg DM
Whole crop silage	$ 0.20 / kg DM
Silage making on farm	$ 250 / ha ($0.06/kg DM)
N fertiliser	$ 0.90 / Kg N

Sources: Hughes (Pers. comm.); Whatman (Pers. comm.); Allison, 1999

APPENDIX D

D.1 Plans with different Lactation Lengths under Varying MS Prices

D.1.1 Plans under $3/kg MS

	Plans	
	1*	2#
Planned start of calving	12 August	12 August
Lactation length (days)	270	300
MS/cow (kg)	370	430
MS/ha (kg)	977	1,034
Stocking rate (Cows/ha)	2.64	2.40
Pasture area conserved (% of pasture area)	4	3
Spring N fertilizer (kg N/ha)	69	74
Autumn N fertilizer (kg N/ha)	131	126
Total N fertilizer (kg N/ha)	*200*	*200*
Feed use:		
Grazing off (% of herd)	44	66
Grazed pasture (kg DM/ha)	11,900	12,800
Grazed pasture (kg DM/lactating cow)	4,510	5,300
Home made pasture silage (Kg DM/cow)	69	62
Bought in pasture silage (Kg DM/cow)	0	0
Barley grain (Kg DM/cow)	0	64
Total bought in supplements (kg DM/cow)	0	64
Total Gross Margin ($/ha)	900	993
Total variable cost ($/kg MS)	2.08	2.17

* Lactation length fixed at 270 days
# Lactation length allowed to vary – optimal was 300 days

D.1.2 Plans under $3.6/kg MS

	Plans	
	1*	2#
Planned start of calving	12 August	12 August
Lactation length (days)	270	300
MS/cow (kg)	370	430
MS/ha (kg)	1,019	1,060
Stocking rate (Cows/ha)	2.76	2.46
Pasture area conserved (% of pasture area)	2	2
Spring N fertilizer (kg N/ha)	77	57
Autumn N fertilizer (kg N/ha)	123	143
Total N fertilizer (kg N/ha)	*200*	*200*
Feed use:		
Grazing off (% of herd)	60	84
Grazed pasture (kg DM/ha)	12,500	13,200
Grazed pasture (kg DM/lactating cow)	4,540	5,360
Home made pasture silage (Kg DM/cow)	28	35
Bought in pasture silage (Kg DM/cow)	0	0
Barley grain (Kg DM/cow)	0	64
Total bought in supplements (kg DM/cow)	0	64
Total Gross Margin ($/ha)	1,500	1,638
Total variable cost ($/kg MS)	2.13	2.05

* Lactation length fixed at 270 days
# Lactation length allowed to vary – optimal was 300 days

D.1.3 Plans under $4.2/kg MS

	Plans	
	1*	**2#**
Planned start of calving	12 August	12 August
Lactation length (days)	270	300
MS/cow (kg)	370	430
MS/ha (kg)	1,057	1,120
Stocking rate (Cows/ha)	2.86	2.60
Pasture area conserved (% of pasture area)	0	0
Spring N fertilizer (kg N/ha)	67	55
Autumn N fertilizer (kg N/ha)	133	145
Total N fertilizer (kg N/ha)	*200*	*200*
Feed use:		
Grazing off (% of herd)	77	100
Grazed pasture (kg DM/ha)	13,072	13,625
Grazed pasture (kg DM/lactating cow)	4,570	5,200
Home made pasture silage (Kg DM/cow)	0	0
Bought in pasture silage (Kg DM/cow)	0	173
Barley grain (Kg DM/cow)	0	64
Total bought in supplements (kg DM/cow)	0	237
Total Gross Margin ($/ha)	2,120	2,285
Total variable cost ($/kg MS)	2.19	2.17

* Lactation length fixed at 270 days
# Lactation length allowed to vary – optimal was 300 days

D.1.4 Plans under $4.8/kg MS

	Plans	
	1*	2#
Planned start of calving	12 August	12 August
Lactation length (days)	270	300
MS/cow (kg)	370	430
MS/ha (kg)	1,478	1,720
Stocking rate (Cows/ha)	4.00	4.00
Pasture area conserved (% of pasture area)	0	0
Spring N fertilizer (kg N/ha)	67	55
Autumn N fertilizer (kg N/ha)	133	145
Total N fertilizer (kg N/ha)	*200*	*200*
Feed use:		
Grazing off (% of herd)	97	100
Grazed pasture (kg DM/ha)	13,500	13,700
Grazed pasture (kg DM/lactating cow)	3,380	3,400
Home made pasture silage (Kg DM/cow)	0	0
Bought in pasture silage (Kg DM/cow)	1,250	1,980
Barley grain (Kg DM/cow)	0	148
Total bought in supplements (kg DM/cow)	1,250	2,128
Total Gross Margin ($/ha)	2,790	3,086
Total variable cost ($/kg MS)	2.91	3.01

* Lactation length fixed at 270 days
# Lactation length allowed to vary – optimal was 300 days

D.2 Plans for Reducing the Seasonality of Milk Production under Varying MS Prices

D.2.1 Plans under $3/kg MS

	Plans					
	Base	**1**	**2**	**3**	**4**	**5**
% of herd calving in autumn	0	20	40	60	80	100
Stocking rate (Cows/ha)	2.40	2.39	2.33	2.23	2.13	2.03
MS/cow (kg)	430	430	430	430	430	430
MS/ha (kg)	1,034	1,029	1,000	960	916	875
Lactation length (days)	300	300	300	300	300	300
Pasture area conserved (% of pasture area)	3	5	13	24	33	43
Spring N fertilizer (kg N/ha)	57	55	0	0	0	0
Autumn N fertilizer (kg N/ha)	143	145	200	200	200	200
Total N fertilizer (kg N/ha)	*200*	*200*	*200*	*200*	*200*	*200*
Feed use:						
Grazing off (% of herd)	66	72	60	40	20	0
Grazed pasture (kg DM/ha)	12,800	12,700	11,960	10,990	9,900	8,800
Grazed pasture (kg DM/cow)	5,335	5,308	5,144	4,900	4,600	4,330
Home made pasture silage (Kg DM/cow)	58	107	269	495	736	986
Bought in pasture silage (Kg DM/cow)	0	0	0	0	0	0
Barley grain (Kg DM/cow)	64	39	45	57	93	155
Total supplements (kg DM/cow)	122	146	314	552	829	1,141
Total Gross Margin ($)	172,510	160,233	145,551	128,800	113,648	93,018
Marginal cost ($)	-	12,277	26,959	43,710	58,862	79,492
Marginal cost (% of Base Gross Margin)	-	7,1	15.6	25.3	34.1	46.1
Marginal cost over whole season ($/kg MS)		0.07	0.16	0.27	0.38	0.53
Average variable production cost ($/kg MS)	2.02	2.08	2.14	2.21	2.27	2.37
Winter premium (May, June & July) required to equal base plan gross margin ($/kg MS)		0.41	0.72	0.98	1.17	1.43
Milk flow at peak month (% of total production)	13.1	12.4	11.6	10.8	11.3	13.0

D.2.2 Plans under $3.6/kg MS

	Plans					
	Base	**1**	**2**	**3**	**4**	**5**
% of herd calving in autumn	0	20	40	60	80	100
Stocking rate (Cows/ha)	2.46	2.46	2.44	2.41	2.39	2.35
MS/cow (kg)	430	430	430	430	430	430
MS/ha (kg)	1,060	1,060	1,049	1,036	1,028	1,010
Lactation length (days)	300	300	300	300	300	300
Pasture area conserved (% of pasture area)	2	8	10	17	23	28
Spring N fertilizer (kg N/ha)	57	55	0	0	0	0
Autumn N fertilizer (kg N/ha)	143	145	200	200	200	200
Total N fertilizer (kg N/ha)	*200*	*200*	*200*	*200*	*200*	*200*
Feed use:						
Grazing off (% of herd)	84	82	60	40	20	0
Grazed pasture (kg DM/ha)	13,204	12,888	12,260	11,481	10,684	9,744
Grazed pasture (kg DM/cow)	5,358	5,239	5,024	4,764	4,470	4,146
Home made pasture silage (Kg DM/cow)	33	158	232	384	525	662
Bought in pasture silage (Kg DM/cow)	0	41	202	332	476	619
Barley grain (Kg DM/cow)	64	39	45	57	93	155
Total supplements (kg DM/cow)	122	238	479	773	1,094	1,436
Total Gross Margin ($)	278,489	270,463	256,121	239,938	222,587	195,020
Marginal cost ($)	-	8,026	22,368	38,551	55,902	83,469
Marginal cost (% of Base Gross Margin)	-	3	8	14	20	30
Marginal cost over whole season ($/kg MS)		0.04	0.13	0.22	0.32	0.49
Average variable production cost ($/kg MS)	2.05	2.10	2.16	2.24	2.33	2.46
Winter premium (May, June & July) required to equal base plan gross margin ($/kg MS)		0.26	0.57	0.80	0.99	1.30
Milk flow at peak month (% of total production)	13.1	12.4	11.6	10.8	11.3	13.0

D.2.3 Plans under $4.2/kg MS

Organisation of optimal plans	Plans					
	Base	**1**	**2**	**3**	**4**	**5**
% of herd calving in autumn	0	20	40	60	80	100
Stocking rate (Cows/ha)	2.62	2.68	2.74	2.82	3.02	3.30
MS/cow (kg)	430	430	430	430	430	430
MS/ha (kg)	1,127	1,152	1,179	1,214	1,297	1,418
Lactation length (days)	300	300	300	300	300	300
Pasture area conserved (% of pasture area)	0	0	0	0	0	0
Spring N fertilizer (kg N/ha)	57	45	20	0	0	0
Autumn N fertilizer (kg N/ha)	143	155	180	200	200	200
Total N fertilizer (kg N/ha)	*200*	*200*	*200*	*200*	*200*	*200*
Feed use:						
Grazing off (% of herd)	100	100	87	66	51	33
Grazed pasture (kg DM/ha)	13,654	13,698	13,412	12,977	12,569	11,987
Grazed pasture (kg DM/cow)	5,209	5,112	4,893	4,596	4,167	3,636
Home made pasture silage (Kg DM/cow)	0	0	0	0	0	0
Bought in pasture silage (Kg DM/cow)	139	267	514	823	1,246	1,717
Barley grain (Kg DM/cow)	97	77	63	67	91	158
Total supplements (kg DM/cow)	236	344	578	890	1,337	1,875
Total Gross Margin ($)	389,872	386,078	375,668	361,811	342,289	313,140
Marginal cost ($)	-	3,794	14,204	28,061	47,583	76,732
Marginal cost (% of Base Gross Margin)	-	1.00	3.6	7.2	12.2	19.7
Marginal cost over whole season ($/kg MS)		0.02	0.07	0.14	0.23	0.35
Average variable cost ($/kg MS)	2.17	2.23	2.33	2.45	2.65	2.90
Winter premium required to equal base plan gross margin ($/kg MS)		0.14	0.39	0.57	0.72	0.85
Milk flow at peak month (% of total production)	13.0	12.4	11.8	11.3	10.9	13.0

D.2.4 Plans under $4.8/kg MS

	Plans					
	Base	**1**	**2**	**3**	**4**	**5**
% of herd calving in autumn	0	20	40	60	80	100
Stocking rate (Cows/ha)	4	4	4	4	4	4
MS/cow (kg)	430	430	430	430	430	430
MS/ha (kg)	1,720	1,720	1,720	1,720	1,720	1,720
Lactation length (days)	300	300	300	300	300	300
Pasture area conserved (% of pasture area)	0	0	0	0	0	0
Spring N fertilizer (kg N/ha)	57	55	0	0	0	0
Autumn N fertilizer (kg N/ha)	143	145	200	200	200	200
Total N fertilizer (kg N/ha)	*200*	*200*	*200*	*200*	*200*	*200*
Feed use:						
Grazing off (% of herd)	100	100	100	91	68	54
Grazed pasture (kg DM/ha)	13,691	13,720	13,718	13,440	12,847	12,482
Grazed pasture (kg DM/cow)	3,423	3,430	3,430	3,360	3,212	3,120
Home made pasture silage (Kg DM/cow)	0	0	0	0	0	0
Bought in pasture silage (Kg DM/cow)	1,816	1,836	1,832	1,898	2,042	2,120
Barley grain (Kg DM/cow)	39	19	21	25	31	44
Total supplements (kg DM/cow)	1,855	1,855	1,853	1,923	2,073	2,164
Total Gross Margin ($)	591,272	584,109	575,156	563,387	549,960	536,000
Marginal cost ($)	-	7,163	16,166	27,885	41,313	55,272
Marginal cost (% of Base Gross Margin)	-	1.2	2.7	4.7	7.0	9.3
Marginal cost over whole season ($/kg MS)		0.02	0.06	0.10	0.14	0.19
Average variable production cost ($/kg MS)	2.78	2.80	2.83	2.87	2.92	2.97
Winter premium (May, June & July) required to equal base plan gross margin ($/kg MS)		0.16	0.27	0.36	0.44	0.55
Milk flow at peak month (% of total production)	13.1	12.3	11.5	11.1	11.0	12.0

D.3 Optimal Plans under Different Pricing Schemes

D.3.1 Schemes Involving Winter Premiums

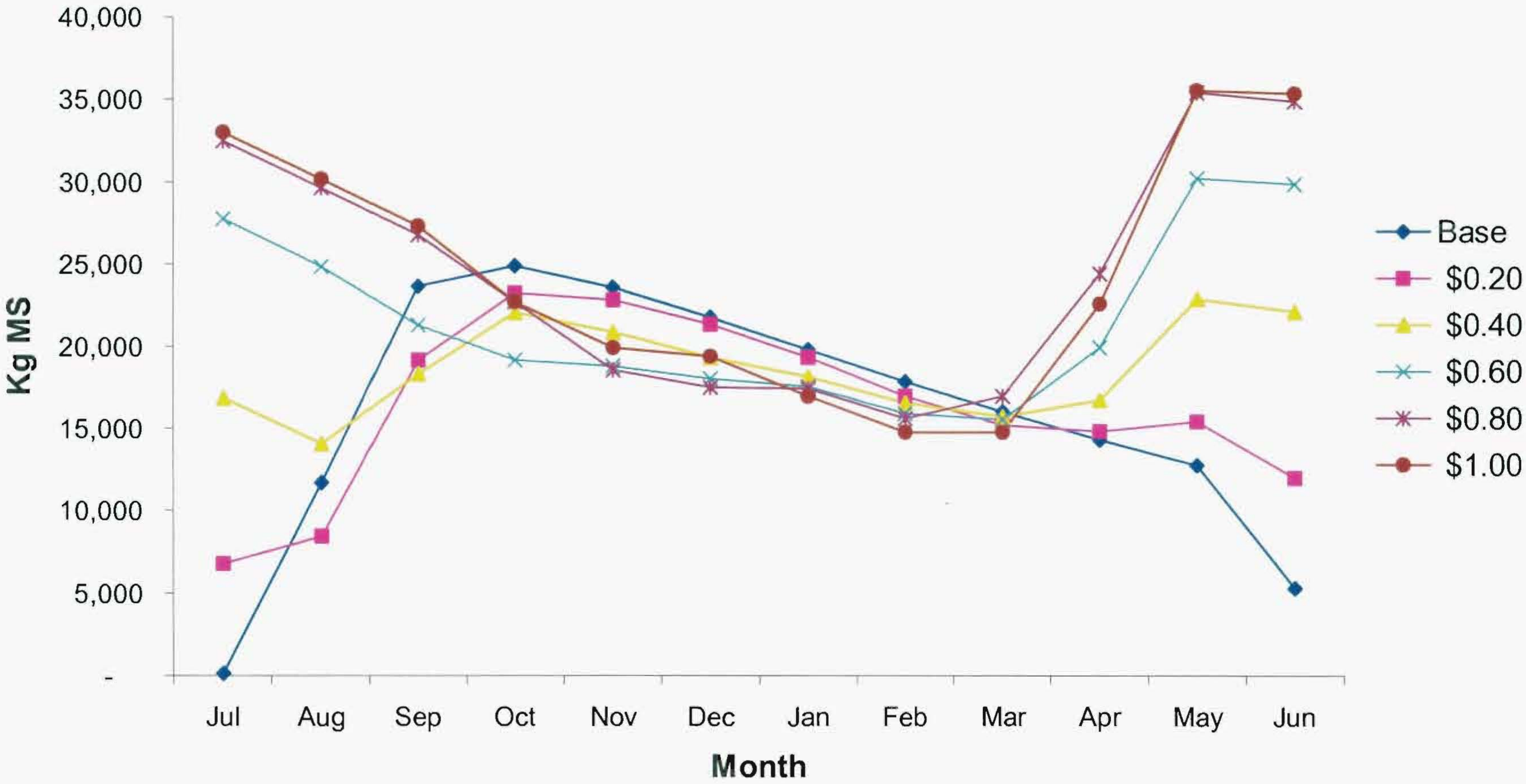
D.3.1.1 Base Milksolids Price = $3.6/kg MS

	Premiums paid in May, June, and July ($/kg MS)					
	0.00	**0.40**	**0.60**	**0.80**	**1.00**	**1.20**
Stocking rate (Cows/ha)	2.46	2.51	2.56	2.68	2.80	2.99
Cows calving in the month of (% of total)						
July						
August	67	65	51	31	-	-
September	33	20	28	33	14	-
October	-	15	-	-	23	15
November	-	-	11	-	-	-
December	-	-	-	-	-	-
January	-	-	-	-	-	-
February	-	-	-	-	-	10
March	-	-	-	14	11	16
April	-	-	9	22	23	25
May	-	-	-	-	28	34
June	-	-	-	-	-	-
MS/cow (kg)	430	430	430	430	430	430
MS/ha (kg)	1,060	1,078	1,101	1,152	1,202	1,286
Lactation length (days)	300	300	300	300	300	300
Pasture area conserved (% of pasture area)	2	1.7	1.4	0.7	0.6	-
N fertilizer (kg N/ha)	200	200	200	200	200	200
Feed use:						
Home made pasture silage (Kg DM/cow)	58	14	11	5	5	-
Bought in pasture silage (Kg DM/cow)	0	90	145	529	1,001	1,348
Barley grain (Kg DM/cow)	64	65	55	6		5
Total supplements (kg DM/cow)	102	169	211	540	1,006	1,353
Total Gross Margin ($)	278,489	292,027	297,018	303,160	313,891	327,195
Average variable production cost ($/kg MS)	2.05	2.06	2.11	2.23	2.37	2.52
Average milksolids price ($/kg MS)	3.60	3.65	3.69	3.78	3.90	4.02
Milk flow at peak month (% of total production)	13.1	12.5	12.1	11.4	10.8	11.9
Peak month	Oct	Nov	Nov	Oct	May	Jun

D.3.1.2 Base Milksolids Price = $4.2/kg MS

	Premiums paid in May, June, and July ($/kg MS)					
	0.00	**0.20**	**0.40**	**0.60**	**0.80**	**1.00**
Stocking rate (Cows/ha)	2.62	2.67	3.06	3.54	4.00	4.00
Cows calving in the month of (% of total)						
July	-	-	-	-	-	-
August	67	42	-	-	-	-
September	33	36	39	-	-	-
October	-	-	-	3	-	-
November	-	2	3	8	-	-
December	-	1	9	15	19	14
January	-	-	-	-	-	-
February	-	-	10	16	18	21
March	-	4	6	11	14	10
April	-	10	16	17	23	26
May	-	4	18	30	25	29
June	-	-	-	-	-	-
MS/cow (kg)	430	430	430	430	430	430
MS/ha (kg)	1,127	1,149	1,315	1,522	1,720	1,720
Lactation length (days)	300	300	300	300	300	300
Pasture area conserved (% of pasture area)	-	-	-	-	-	-
N fertilizer (kg N/ha)	200	200	200	200	200	200
Feed use:						
Home made pasture silage (Kg DM/cow)	-	-	-	-	-	-
Bought in pasture silage (Kg DM/cow)	139	354	1,051	1,692	2,100	2,143
Barley grain (Kg DM/cow)	97	3	-	13	27	33
Total supplements (kg DM/cow)	236	357	1,051	1,705	2,127	2,176
Total Gross Margin ($)	389,870	398,440	404,770	417,630	434,100	454,770
Average variable production cost ($/kg MS)	2.17	2.20	2.50	2.79	3.00	3.00
Average milksolids price ($/kg MS)	4.20	4.23	4.31	4.40	4.48	4.56
Milk flow at peak month (% of total production)	13.0	11.9	10.2	11.7	12.1	12.2
Peak month	Oct	Oct	May	May	May	May

D.3.1.3 Milk supply patterns resulting from varying levels of winter premiums, with a base payout of $4.2/kg MS



D.3.2 Schemes Involving Shoulder Premiums

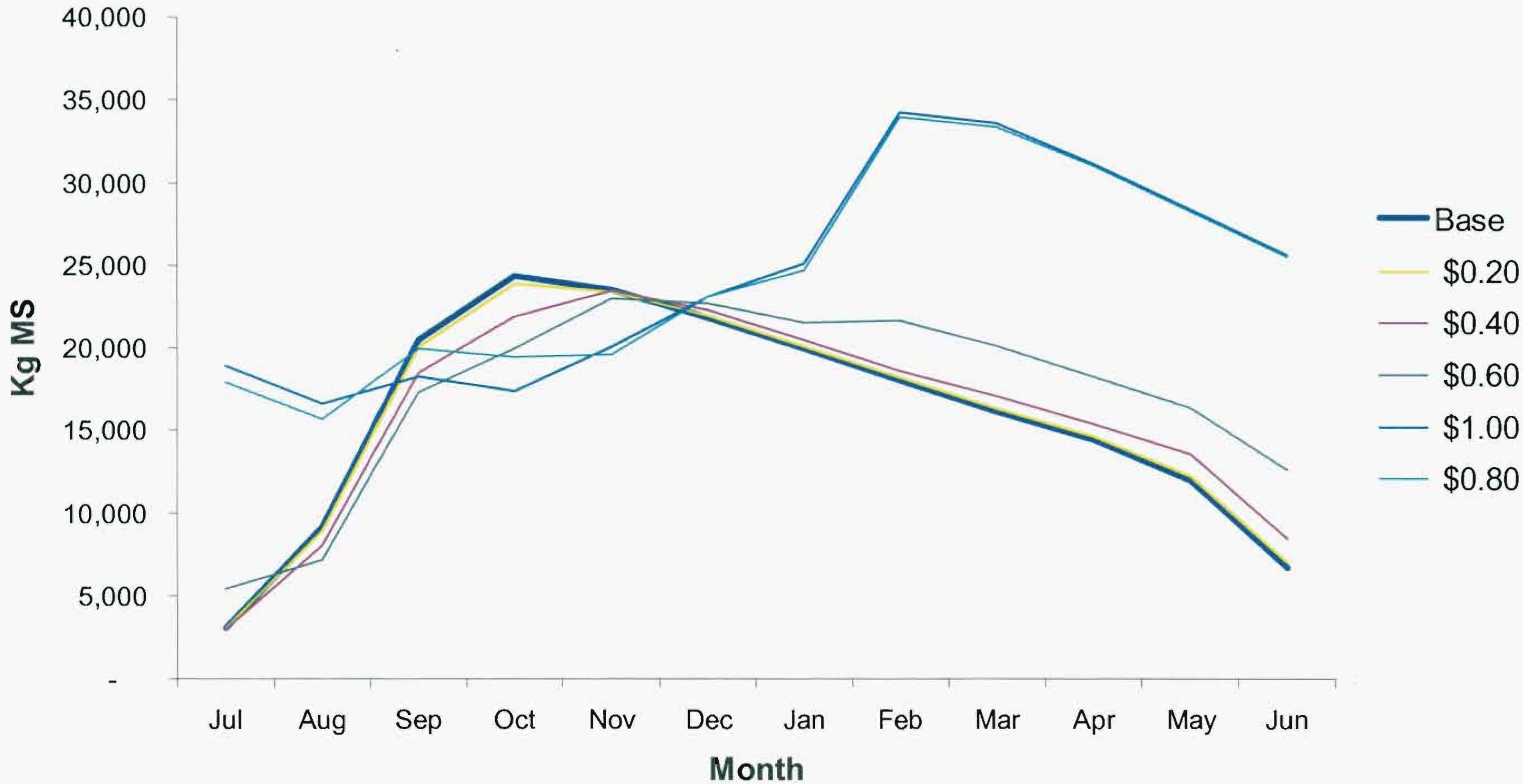
D.3.2.1 Base Milksolids Price = $3.6/kg MS

	Premiums paid in February, March, and April ($/kg MS)					
	0.00	0.40	0.60	0.80	1.00	1.20
Stocking rate (Cows/ha)	2.46	2.50	2.51	2.50	2.49	2.54
Cows calving in the month of (% of total)						
July	-	-	-	-	-	-
August	67	65	72	65	62	59
September	33	30	12	17	18	22
October	-	6	9	9	8	3
November	-	-	7	7	8	11
December	-	-	-	3	5	5
January	-	-	-	-	-	-
February	-	-	-	-	-	-
March	-	-	-	-	-	-
April	-	-	-	-	-	-
May	-	-	-	-	-	-
June	-	-	-	-	-	-
MS/cow (kg)	430	430	430	430	430	430
MS/ha (kg)	1,060	1,075	1,079	1,075	1,072	1,092
Lactation length (days)	300	300	300	300	300	300
Pasture area conserved (% of pasture area)	2	2	2	2	3	2
N fertilizer (kg N/ha)	200	200	200	200	200	200
Feed use:						
Home made pasture silage (Kg DM/cow)	58	22	19	30	36	21
Bought in pasture silage (Kg DM/cow)	0	103	107	102	114	132
Barley grain (Kg DM/cow)	64	5	9	3	-	-
Total supplements (kg DM/cow)	122	130	135	135	150	153
Total Gross Margin ($)	278,489	302,305	311,979	321,797	331,750	341,449
Average variable production cost ($/kg MS)	2.05	2.05	2.06	2.06	2.06	2.07
Average milksolids price ($/kg MS)	3.60	3.70	3.76	3.82	3.87	3.93
Milk flow at peak month (% of total production)	13.1	12.8	12.5	12.2	11.9	12.0
Peak month	Oct	Oct	Nov	Nov	Nov	Nov

D.3.2.2 Base Milksolids Price = $4.2/kg MS

	Premiums paid in February, March, and April ($/kg MS)					
	0.00	**0.20**	**0.40**	**0.60**	**0.80**	**1.00**
Stocking rate (Cows/ha)	2.62	2.65	2.70	2.82	4.00	4.00
Cows calving in the month of (% of total)						
July	-	-	-	-	-	-
August	67	62	55	43	-	-
September	33	33	31	26	31	26
October	-	5	6	-	-	-
November	-	-	8	18	17	25
December	-	-	1	4	15	12
January	-	-	-	10	37	37
February	-	-	-	-	-	-
March	-	-	-	-	-	-
April	-	-	-	-	-	-
May	-	-	-	-	-	-
June	-	-	-	-	-	-
MS/cow (kg)	430	430	430	430	430	430
MS/ha (kg)	1,127	1,140	1,161	1,213	1,720	1,720
Lactation length (days)	300	300	300	300	300	300
Pasture area conserved (% of pasture area)	-	-	-	-	-	-
N fertilizer (kg N/ha)	200	200	200	200	200	200
Feed use:						
Home made pasture silage (Kg DM/cow)	-	-	-	-	-	-
Bought in pasture silage (Kg DM/cow)	139	193	230	645	2,174	2,180
Barley grain (Kg DM/cow)	97	95	75	-	5	4
Total supplements (kg DM/cow)	236	288	305	645	2,179	2,184
Total Gross Margin ($)	389,870	403,550	413,365	422,830	430,890	450,570
Average variable production cost ($/kg MS)	2.17	2.18	2.20	2.32	3.00	3.00
Average milksolids price ($/kg MS)	4.20	4.25	4.31	4.37	4.47	4.54
Milk flow at peak month (% of total production)	13.0	12.6	12.3	11.2	11.6	11.7
Peak month	Oct	Oct	Nov	Nov	Feb	Feb

D.3.2.3 Milk supply patterns resulting from varying levels of shoulder premiums, with a base payout of $4.2/kg MS



D.3.3 Schemes involving both shoulder and winter premiums

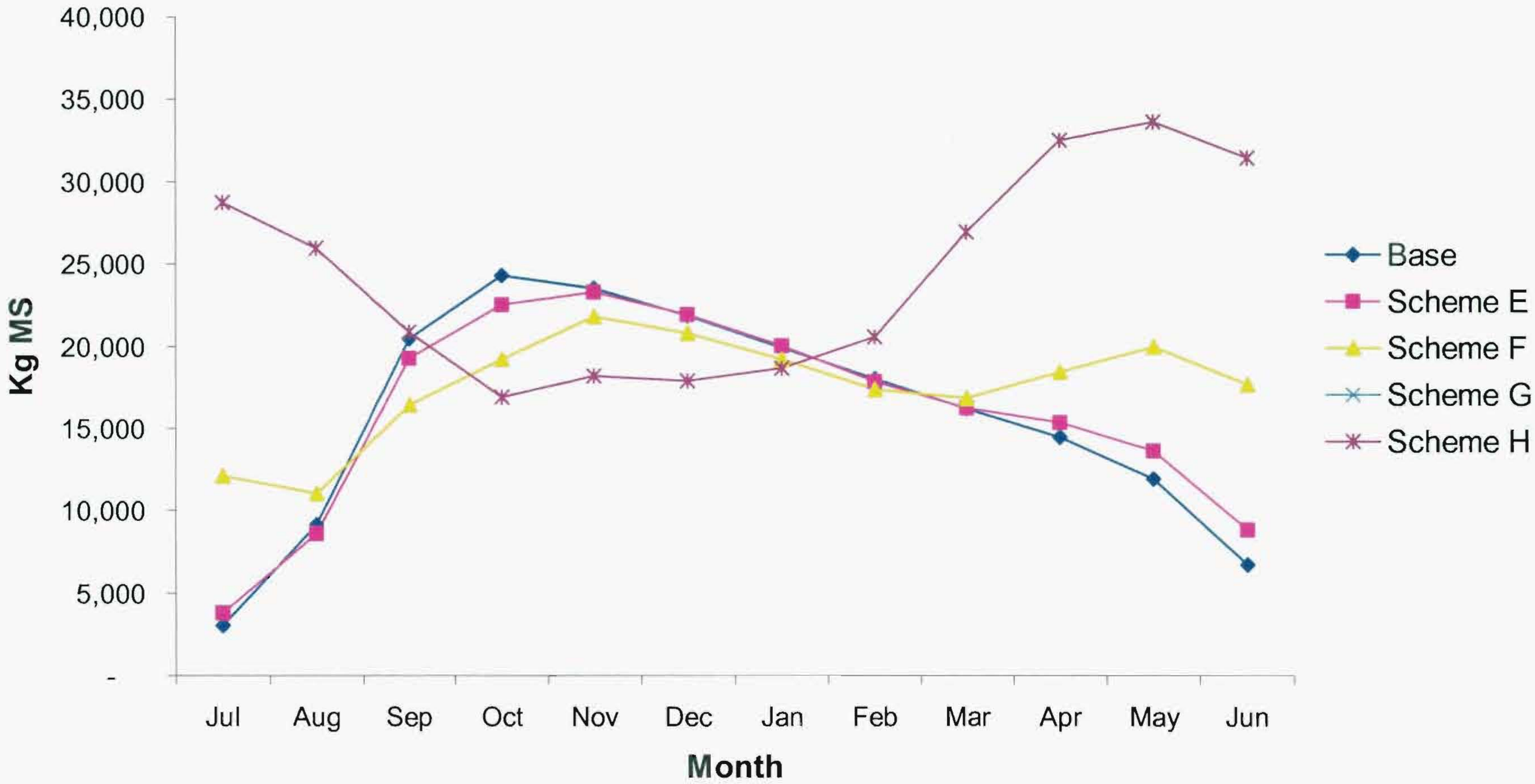
D.3.3.1 Base Milksolids Price = $3.6/kg MS

	Scheme				
	Base	**A**	**B**	**C**	**D**
Stocking rate (Cows/ha)	2.46	2.51	2.60	2.82	3.54
Cows calving in the month of (% of total)					
July	-	-	-	-	-
August	67	64	45	-	-
September	33	19	30	33	-
October	-	8	-	-	-
November	-	8	16	10	25
December	-	-	-	25	8
January	-	-	-	-	13
February	-	-	-	7	10
March	-	-	4	6	11
April	-	-	5	20	32
May	-	-	-	-	-
June	-	-	-	-	-
MS/cow (kg)	430	430	430	430	430
MS/ha (kg)	1,060	1,077	1,116	1,214	1,524
Lactation length (days)	300	300	300	300	300
Pasture area conserved (% of pasture area)	2.0	1.8	0.3	2.3	0
N fertilizer (kg N/ha)	200	200	200	200	200
Feed use:					
Home made pasture silage (Kg DM/cow)	58	22	4	25	0
Bought in pasture silage (Kg DM/cow)	0	125	215	857	1,718
Barley grain (Kg DM/cow)	64	-	-	-	-
Total supplements (kg DM/cow)	122	147	219	882	1,718
Total Gross Margin ($)	278,490	309,240	335,840	367,410	408,100
Average variable production cost ($/kg MS)	2.05	2.06	2.13	2.37	2.79
Average milksolids price ($/kg MS)	3.60	3.74	3.90	4.15	4.37
Milk flow at peak month (% of total production)	13.1	12.5	12.2	10.2	11.5
Peak month	Oct	Nov	Nov	Dec	May

D.3.3.2 Base Milksolids Price = \$4.2/kg MS

	Scheme				
	Base	E	F	G	H
Stocking rate (Cows/ha)	2.62	2.62	2.88	4.00	4.00
Cows calving in the month of (% of total)					
July	-	-	-	-	-
August	67	57	18	-	-
September	33	30	28	-	-
October	-	-	-	-	-
November	-	7	15	17	17
December	-	-	5	17	17
January	-	-	-	12	12
February	-	-	7	19	19
March	-	5	5	13	13
April	-	-	21	21	21
May	-	-	-	-	-
June	-	-	-	-	-
MS/cow (kg)	430	430	430	430	430
MS/ha (kg)	1,127	1,127	1,239	1,720	1,720
Lactation length (days)	300	300	300	300	300
Pasture area conserved (% of pasture area)	-	-	-	-	-
N fertilizer (kg N/ha)	200	200	200	200	200
Feed use:					
Home made pasture silage (Kg DM/cow)	-	-	-	-	-
Bought in pasture silage (Kg DM/cow)	139	243	759	2,180	2,180
Barley grain (Kg DM/cow)	97	-	-	-	-
Total supplements (kg DM/cow)	236	243	759	2,180	2,180
Total Gross Margin (\$)	389,870	407,180	420,750	437,580	465,920
Average variable production cost (\$/kg MS)	2.17	2.18	2.37	2.99	2.99
Average milksolids price (\$/kg MS)	4.20	4.27	4.37	4.49	4.59
Milk flow at peak month (% of total production)	13.0	12.2	10.3	11.5	11.5
Peak month	Oct	Nov	Nov	May	May

D.3.3.3 Milk supply patterns resulting from varying levels of winter and shoulder premiums, with a base payout of $4.2/kg MS



APPENDIX E

The Linear Programming Model in Algebraic Form

(See p. 192 for list of variable definitions)

MAX

-613 X1 - 613 X2 - 511 X3 - 511 X4 - 511 X5 - 511 X6 - 511 X7 - 511 X8 - 511 X9 - 613 X10 - 613 X11 - 613 X12 - 613 X13 - 613 X14 - 613 X15 - 613 X16 - 613 X17 - 613 X18 - 613 X19 - 613 X20 - 613 X21 - 613 X22 - 613 X23 - 613 X24 - 613 X25 - 613 X26 - 639 X27 - 639 X28 - 537 X29 - 537 X30 - 537 X31 - 537 X32 - 537 X33 - 537 X34 - 537 X35 - 639 X36 - 639 X37 - 639 X38 - 639 X39 - 639 X40 - 639 X41 - 639 X42 - 639 X43 - 639 X44 - 639 X45 - 639 X46 - 639 X47 - 639 X48 - 639 X49 - 639 X50 - 639 X51 - 639 X52 - 639 X53 - 639 X54 - 537 X55 - 537 X56 - 537 X57 - 537 X58 - 537 X59 - 537 X60 - 537 X61 - 639 X62 - 639 X63 - 639 X64 - 639 X65 - 639 X66 - 639 X67 - 639 X68 - 639 X69 - 639 X70 - 639 X71 - 639 X72 - 639 X73 - 639 X74 - 639 X75 - 639 X76 - 639 X77 - 639 X78 + 4.2 X79 + 4.2 X80 + 4.2 X81 + 4.2 X82 + 4.2 X83 + 4.2 X84 + 4.2 X85 + 4.2 X86 + 4.2 X87 + 4.2 X88 + 4.2 X89 + 4.2 X90 - 280 X91 - .9 X92 - .9 X93 - .9 X94 - .9 X95 - .9 X96 - .9 X97 - .9 X98 - .9 X99 - .9 X100 - .9 X101 - .9 X102 - .9 X103 - .9 X104 - .9 X105 - .9 X106 - .9 X107 - .9 X108 - .9 X109 - .9 X110 - .9 X111 - 250 X164 - 250 X165 - 250 X166 - .22 X167 - .33 X194 - 0.20 X221 - 180 X249 - 180 X251 - 180 X253 - 180 X255 - 180 X257 - 180 X259 - 180 X261 - 180 X263 - 180 X265 - 180 X267 - 180 X269 - 180 X271 - 180 X273 - 180 X275 - 180 X277 - 180 X279 - 180 X281 - 180 X283 - 180 X285 - 180 X287 - 180 X289 - 180 X291 - 180 X293 - 180 X295 - 180 X297 - 180 X299 - 120 X301 - 120 X303 - 120 X305 - 120 X307 - 120 X309 - 120 X311 - 120 X313 - 120 X315 - 120 X317 - 120 X319 - 120 X321 - 120 X323 120 X325 - 120 X327 - 120 X329 - 120 X331 - 120 X333 - 120 X335 - 120 X337 - 120 X339 - 120 X341 - 120 X343 - 120 X345 - 120 X347 - 120 X349 - 120 X351 - 120 X353 - 120 X355 - 120 X357 - 120 X359 - 120 X361 - 120 X363 - 120 X365 - 120 X367 - 120 X369 - 120 X371 - 120 X373 - 120 X375 - 120 X377 - 120 X379 - 120 X381 - 120 X383 - 120 X385 - 120 X387 - 120 X389 - 120 X391 - 120 X393 - 120 X395 - 120 X397 - 120 X399 - 120 X401 - 120 X403 - .18 X404

ST

MILK JUL) -47.43 X1 - 22.03 X2 - 13.34 X9 - 27.49 X10 - 29.13 X11 - 30.85 X12 - 32.64 X13 - 34.51 X14 - 36.44 X15 - 37.78 X16 - 39.76 X17 - 42.00 X18 - 42.50 X19 - 45.57 X20 - 46.54 X21 - 48.44 X22 - 50.13 X23 - 51.46 X24 - 52.14 X25 - 51.53 X26 - 48.10 X27 - 22.34 X28 - 03.19 X32 - 12.01 X33 - 24.77 X34 - 26.28 X35 - 27.87 X36 - 29.54 X37 - 31.29 X38 - 33.11 X39 - 35.00 X40 - 36.95 X41 - 38.96 X42 - 41.02 X43 - 43.10 X44 - 45.17 X45 - 45.17 X46 - 47.20 X47 - 49.12 X48 - 50.84 X49 - 52.19 X50 - 52.88 X51 - 52.26 X52 - 51.70 X53 - 24.02 X54 - 01.85 X58 - 12.91 X59 - 26.62 X60 - 28.25 X61 - 29.97 X62 - 31.76 X63 - 33.63 X64 - 35.59 X65 - 37.62 X66 - 39.72 X67 - 41.89 X68 - 44.10 X69 - 46.40 X70 - 46.33 X71 - 48.56 X72 - 50.74 X73 - 52.81 X74 - 54.65 X75 - 56.10 X76 - 56.84 X77 - 56.18 X78 + X79 = 0

MILK AUG) -52.14 X1 - 51.53 X2 - 47.43 X3 - 22 X4 - 13.34 X11 - 27.49 X12 - 29.13 X13 - 30.85 X14 - 32.64 X15 - 33.87 X16 - 35.75 X17 - 38.00 X18 - 38.40 X19 - 41.48 X20 - 42.50 X21 - 44.54 X22 - 46.54 X23 - 48.44 X24 - 50.13 X25 - 51.46 X26 - 52.88 X27 - 52.26 X28 - 48.10 X29 - 22.34 X30 - 08.82 X31 - 12.01 X35 - 24.77 X36 - 26.28 X37 - 27.87 X38 - 29.54 X39 - 31.29 X40 - 33.11 X41 - 35.00 X42 - 36.95 X43 - 38.96 X44 - 41.02 X45 - 41.02 X46 - 43.10 X47 - 45.17 X48 - 47.20 X49 - 49.12 X50 - 50.84 X51 - 52.19 X52 - 56.84 X53 - 56.18 X54 - 51.70 X55 - 24.02 X56 - 09.48 X57 - 12.91 X61 - 26.62 X62 - 28.25

X63 - 29.97 X64 - 31.76 X65 - 33.63 X66 - 35.59 X67 - 37.62 X68 - 39.72 X69 - 42.00 X70 - 41.89 X71 - 44.10 X72 - 46.33 X73 - 48.56 X74 - 50.74 X75 - 52.81 X76 - 54.65 X77 - 56.10 X78 + X80 = 0

MILK SEP) -50.13 X1 - 51.46 X2 - 52.14 X3 - 52 X4 - 47 X5 - 22 X6 - 13.03 X7 - 13.34 X13 - 27.49 X14 - 29.13 X15 - 30.21 X16 - 31.95 X17 - 34.20 X18 - 34.51 X19 - 37.47 X20 - 38.42 X21 - 40.45 X22 - 42.50 X23 - 44.54 X24 - 46.54 X25 - 48.44 X26 - 50.84 X27 - 52.19 X28 - 52.88 X29 - 52.26 X30 - 47.20 X31 - 31.16 X32 - 22.34 X33 - 12.01 X37 - 24.77 X38 - 26.28 X39 - 27.87 X40 - 29.54 X41 - 31.29 X42 - 33.11 X43 - 35.00 X44 - 36.95 X45 - 36.95 X46 - 38.96 X47 - 41.02 X48 - 43.10 X49 - 45.17 X50 - 47.20 X51 - 49.12 X52 - 54.65 X53 - 56.10 X54 - 56.84 X55 - 56.18 X56 - 51.70 X57 - 35.08 X58 - 24.02 X59 - 12.91 X63 - 26.62 X64 - 28.25 X65 - 29.97 X66 - 31.76 X67 - 33.63 X68 - 35.59 X69 - 37.89 X70 - 37.62 X71 - 39.72 X72 - 41.89 X73 - 44.10 X74 - 46.33 X75 - 48.56 X76 - 50.74 X77 - 52.81 X78 + X81 = 0

MILK OCT) -46.54 X1 - 48.44 X2 - 50.13 X3 - 51 X4 - 52 X5 - 52 X6 - 52.53 X7 - 39.00 X8 - 16.39 X9- 13.34 X15 - 26.80 X16 - 28.43 X17 - 30.70 X18 - 30.85 X19 - 33.67 X20 - 34.51 X21 - 36.44 X22 - 38.42 X23 - 40.45 X24 - 42.50 X25 - 44.54 X26 - 47.20 X27 - 49.12 X28 - 50.84 X29 - 52.19 X30 - 52.00 X31 - 52.26 X32 - 52.26 X33 - 48.10 X34 - 22.34 X35 - 12.01 X39 - 24.77 X40 - 26.28 X41 - 27.87 X42 - 29.54 X43 - 31.29 X44 - 33.11 X45 - 33.11 X46 - 35.00 X47 - 36.95 X48 - 38.96 X49 - 41.02 X50 - 43.10 X51 - 45.17 X52 - 50.74 X53 - 52.81 X54 - 54.65 X55 - 56.10 X56 - 56.84 X57 - 56.18 X58 - 56.18 X59 - 51.70 X60 - 24.02 X61 - 12.91 X65 - 26.62 X66 - 28.25 X67 - 29.97 X68 - 31.76 X69 - 34.06 X70 - 33.63 X71 - 35.59 X72 - 37.62 X73 - 39.72 X74 - 41.89 X75 - 44.10 X76 - 46.33 X77 - 48.56 X78 + X82 = 0

MILK NOV) -42.50 X1 - 44.54 X2 - 46.54 X3 - 48 X4 - 50 X5 - 51 X6 - 52.46 X7 - 53.19 X8 - 52.23 X9 - 47.43 X10 - 22.03 X11 - 12.65 X17 - 14.90 X18 - 27.49 X19 - 30.16 X20 - 30.85 X21 - 32.64 X22 - 34.51 X23 - 36.44 X24 - 38.42 X25 - 40.45 X26 - 43.10 X27 - 45.17 X28 - 47.20 X29 - 49.12 X30 - 49.96 X31 - 52.19 X32 - 52.19 X33 - 52.88 X34 - 52.26 X35 - 48.10 X36 - 22.34 X37 - 12.01 X41 - 17.42 X42 - 26.28 X43 - 27.87 X44 - 29.54 X45 - 29.54 X46 - 31.29 X47 - 33.11 X48 - 35.00 X49 - 36.95 X50 - 38.96 X51 - 41.02 X52 - 46.33 X53 - 48.56 X54 - 50.74 X55 - 52.81 X56 - 54.65 X57 - 56.10 X58 - 56.10 X59 - 56.84 X60 - 56.18 X61 - 51.70 X62 - 24.02 X63 - 12.91 X67 - 18.72 X68 - 28.25 X69 - 30.55 X70 - 29.97 X71 - 31.76 X72 - 33.63 X73 - 35.59 X74 - 37.62 X75 - 39.72 X76 - 41.89 X77 - 44.10 X78 + X83 = 0

MILK DEC) -38.42 X1 - 40.45 X2 - 42.50 X3 - 45 X4 - 47 X5 - 48 X6 - 49.44 X7 - 51.18 X8 - 52.16 X9 - 52.14 X10 - 51.53 X11 - 47.43 X12 - 22.03 X13 - 14.37 X20 - 27.49 X21 - 29.13 X22 - 30.85 X23 - 32.64 X24 - 34.51 X25 - 36.44 X26 - 38.96 X27 - 41.02 X28 - 43.10 X29 - 45.17 X30 - 46.30 X31 - 49.12 X32 - 49.12 X33 - 50.84 X34 - 52.19 X35 - 52.88 X36 - 52.26 X37 - 48.10 X38 - 22.34 X39 - 12.01 X43 - 17.42 X44 - 26.28 X45 - 26.28 X46 - 27.87 X47 - 29.54 X48 - 31.29 X49 - 33.11 X50 - 35.00 X51 - 36.95 X52 - 41.89 X53 - 44.10 X54 - 46.33 X55 - 48.56 X56 - 50.74 X57 - 52.81 X58 - 52.81 X59 - 54.65 X60 - 56.10 X61 - 56.84 X62 - 56.18 X63 - 51.70 X64 - 24.02 X65 - 03.47 X69 - 15.21 X70 - 26.62 X71 - 28.25 X72 - 29.97 X73 - 31.76 X74 - 33.63 X75 - 35.59 X76 - 37.62 X77 - 39.72 X78 + X84 = 0

MILK JAN) -34.51 X1 - 36.44 X2 - 38.42 X3 - 40 X4 - 42 X5 - 45 X6 - 45.54 X7 - 47.59 X8 - 49.14 X9 - 50.13 X10 - 51.46 X11 - 52.14 X12 - 51.53 X13 - 47.43 X14 - 22.03 X15 - 5.80 X163.34 X22 - 27.49 X23 - 29.13 X24 - 30.85 X25 - 32.64 X26 - 35.00 X27 - 36.95 X28 - 38.96 X29 - 41.02 X30 - 42.20 X31 - 45.17 X32 - 45.17 X33 - 47.20 X34 - 49.12 X35 - 50.84 X36 - 52.19 X37 - 52.88 X38 - 52.26 X39 - 48.10 X40 - 22.34 X41 - 07.35 X42 - 04.66 X45 - 01.72 X46 - 24.77 X47 - 26.28 X48 - 27.87 X49 - 29.54 X50 - 31.29 X51 - 33.11 X52 - 37.62 X53 - 39.72 X54 - 41.89 X55 - 44.10 X56 - 46.33 X57 - 48.56 X58 - 48.56 X59 -

50.74 X60 - 52.81 X61 - 54.65 X62 - 56.10 X63 - 56.84 X64 - 56.18 X65 - 51.70 X66 - 24.02 X67 - 07.90 X68 - 12.91 X72 - 26.62 X73 - 28.25 X74 - 29.97 X75 - 31.76 X76 - 33.63 X77 - 35.59 X78 + X85 = 0

MILK FEB) -30.85 X1 - 32.64 X2 - 34.51 X3 - 36 X4 - 38 X5 - 40 X6 - 41.45 X7 - 43.55 X8 - 45.24 X9 - 46.54 X10 - 48.44 X11 - 50.13 X12 - 51.46 X13 - 52.14 X14 - 51.53 X15 - 46.78 X16 - 28.27 X17 - 7.90 X18 - 13.34 X24 - 27.49 X25 - 29.13 X26 - 31.29 X27 - 33.11 X28 - 35.00 X29 - 36.95 X30 - 38.10 X31 - 41.02 X32 - 41.02 X33 - 43.10 X34 - 45.17 X35 - 47.20 X36 - 49.12 X37 - 50.84 X38 - 52.19 X39 - 52.88 X40 - 52.26 X41 - 48.10 X42 - 22.34 X43 - 07.35 X44 - 12.01 X48 - 24.77 X49 - 26.28 X50 - 27.87 X51 - 29.54 X52 - 33.63 X53 - 35.59 X54 - 37.62 X55 - 39.72 X56 - 41.89 X57 - 44.10 X58 - 44.10 X59 - 46.33 X60 - 48.56 X61 - 50.74 X62 - 52.81 X63 - 54.65 X64 - 56.10 X65 - 56.84 X66 - 56.18 X67 - 51.70 X68 - 33.50 X69 - 07.90 X70 - 12.91 X74 - 26.62 X75 - 28.25 X76 - 29.97 X77 - 31.76 X78 + X86 = 0

MILK MAR) -27.49 X1 - 29.13 X2 - 30.85 X3 - 33 X4 - 35 X5 - 36 X6 - 33.64 X7 - 35.36 X8 - 37.15 X9 - 42.50 X10 - 44.54 X11 - 46.54 X12 - 48.44 X13 - 50.13 X14 - 51.46 X15 - 51.50 X16 - 50.84 X17 - 53.09 X18 - 47.43 X19 - 12.74 X20 - 13.34 X26 - 27.87 X27 - 29.54 X28 - 31.29 X29 - 33.11 X30 - 34.00 X31 - 36.95 X32 - 36.95 X33 - 38.96 X34 - 41.02 X35 - 43.10 X36 - 45.17 X37 - 47.20 X38 - 49.12 X39 - 50.84 X40 - 52.19 X41 - 52.88 X42 - 52.26 X43 - 48.10 X44 - 29.69 X45 - 32.63 X46 - 12.01 X50 - 24.77 X51 - 26.28 X52 - 29.97 X53 - 31.76 X54 - 33.63 X55 - 35.59 X56 - 37.62 X57 - 39.72 X58 - 39.72 X59 - 41.89 X60 - 44.10 X61 - 46.33 X62 - 48.56 X63 - 50.74 X64 - 52.81 X65 - 54.65 X66 - 56.10 X67 - 56.84 X68 - 56.18 X69 - 56.18 X70 - 51.70 X71 - 24.02 X72 - 12.91 X76 - 26.62 X77 - 28.25 X78 + X87 = 0

MILK APR)- 13.34 X2 - 27.49 X3 - 29 X4 - 31 X5 - 33 X6 - 33.64 X7 - 35.36 X8 - 37.15 X9 - 38.42 X10 - 40.45 X11 - 42.50 X12 - 44.54 X13 - 46.54 X14 - 48.44 X15 - 49.49 X16 - 50.77 X17 - 53.02 X18 - 52.14 X19 - 52.56 X20 - 47.43 X21 - 22.03 X22 - 24.77 X27 - 26.28 X28 - 27.87 X29 - 29.54 X30 - 30.40 X31 - 33.11 X32 - 33.11 X33 - 35.00 X34 - 36.95 X35 - 38.96 X36 - 41.02 X37 - 43.10 X38 - 45.17 X39 - 47.20 X40 - 49.12 X41 - 50.84 X42 - 52.19 X43 - 52.88 X44 - 52.26 X45 - 52.26 X46 - 48.10 X47 - 22.34 X48 - 12.01 X52 - 26.62 X53 - 28.25 X54 - 29.97 X55 - 31.76 X56 - 33.63 X57 - 35.59 X58 - 35.59 X59 - 37.62 X60 - 39.72 X61 - 41.89 X62 - 44.10 X63 - 46.33 X64 - 48.56 X65 - 50.74 X66 - 52.81 X67 - 54.65 X68 - 56.10 X69 - 56.10 X70 - 56.84 X71 - 56.18 X72 - 51.70 X73 - 24.02 X74 - 12.91 X78 + X88 = 0

MILK MAY)- 14 X4 - 28 X5 - 29 X6 - 30.13 X7 - 31.90 X8 - 33.35 X9 - 34.51 X10 - 36.44 X11 - 38.42 X12 - 40.45 X13 - 42.50 X14 - 44.54 X15 - 45.90 X16 - 47.75 X17 - 50.00 X18 - 50.13 X19 - 52.49 X20 - 52.14 X21 - 51.53 X22 - 47.43 X23 - 22.03 X24 - 12.01 X28 - 24.77 X29 - 26.28 X30 - 27.00 X31 - 29.54 X32 - 29.54 X33 - 31.29 X34 - 33.11 X35 - 35.00 X36 - 36.95 X37 - 38.96 X38 - 41.02 X39 - 43.10 X40 - 45.17 X41 - 47.20 X42 - 49.12 X43 - 50.84 X44 - 52.19 X45 - 52.19 X46 - 52.88 X47 - 52.26 X48 - 48.10 X49 - 22.34 X50 - 12.91 X54 - 26.62 X55 - 28.25 X56 - 29.97 X57 - 31.76 X58 - 31.76 X59 - 33.63 X60 - 35.59 X61 - 37.62 X62 - 39.72 X63 - 41.89 X64 - 44.10 X65 - 46.33 X66 - 48.56 X67 - 50.74 X68 - 52.81 X69 - 52.81 X70 - 54.65 X71 - 56.10 X72 - 56.84 X73 - 56.18 X74 - 51.70 X75 - 24.02 X76 + X89 = 0

MILK JUN)- 14 X6 - 14.34 X7 - 28.50 X8 - 29.80 X9 - 30.85 X10 - 32.64 X11 - 34.51 X12 - 36.44 X13 - 38.42 X14 - 40.45 X15 - 41.86 X16 - 43.85 X17 - 46.10 X18 - 46.54 X19 - 49.47 X20 - 50.13 X21 - 51.46 X22 - 52.14 X23 - 51.53 X24 - 47.43 X25 - 22.03 X26 - 12.01 X30 - 24.00 X31 - 26.28 X32 - 26.28 X33 - 27.87 X34 - 29.54 X35 - 31.29 X36 - 33.11 X37 - 35.00 X38 - 36.95 X39 - 38.96 X40 - 41.02 X41 - 43.10 X42 - 45.17 X43 - 47.20 X44 - 49.12 X45 - 49.12 X46 - 50.84 X47 - 52.19 X48 - 52.88 X49 - 52.26 X50 - 48.10 X51 - 22.34 X52 - 12.91 X56 - 17.14 X57 - 28.25 X58 - 28.25 X59 - 29.97 X60 - 31.76 X61 - 33.63 X62

- 35.59 X63 - 37.62 X64 - 39.72 X65 - 41.89 X66 - 44.10 X67 - 46.33 X68 - 48.56 X69 - 50.86 X70 - 50.74 X71 - 52.81 X72 - 54.65 X73 - 56.10 X74 - 56.84 X75 - 56.18 X76 - 51.70 X77 - 24.02 X78 + X90 = 0

DMI 1) -175.99 X1 - 186.98 X8 - 188.69 X9 - 193.53 X10 - 200.73 X11 - 209.12 X12 - 215.74 X13 - 226.82 X14 - 236.69 X15 - 240.92 X16 - 247.28 X17 - 253.75 X18 - 262.99 X19 - 266.26 X20 - 268.25 X21 - 268.26 X22 - 265.88 X23 - 258.61 X24 - 247.72 X25 - 212.76 X26 - 175.99 X27 - 184.77 X32 - 184.33 X33 - 186.08 X34 - 188.69 X35 - 193.70 X36 - 200.89 X37 - 209.28 X38 - 215.89 X39 - 226.96 X40 - 236.83 X41 - 241.05 X42 - 247.40 X43 - 253.85 X44 - 263.08 X45 - 266.34 X46 - 268.31 X47 - 268.31 X48 - 265.91 X49 - 258.63 X50 - 247.72 X51 - 212.76 X52 - 175.99 X53 - 184.77 X58 - 184.33 X59 - 186.08 X60 - 188.69 X61 - 193.70 X62 - 200.89 X63 - 209.28 X64 - 215.89 X65 - 226.96 X66 - 236.83 X67 - 241.05 X68 - 247.40 X69 - 253.85 X70 - 263.08 X71 - 266.34 X72 - 268.31 X73 - 268.31 X74 - 265.91 X75 - 258.63 X76 - 247.72 X77 - 212.76 X78 + X138 + X168 + 0.7 X195 + X222 < 0

DMI 2) -212.76 X1 - 175.99 X2 - 186.98 X9 - 188.69 X10 - 193.53 X11 - 200.73 X12 - 209.12 X13 - 215.74 X14 - 226.82 X15 - 236.69 X16 - 240.92 X17 - 247.28 X18 - 253.75 X19 - 262.99 X20 - 266.26 X21 - 268.25 X22 - 268.26 X23 - 265.88 X24 - 258.61 X25 - 247.72 X26 - 212.76 X27 - 175.99 X28 - 184.77 X33 - 184.33 X34 - 186.08 X35 - 188.69 X36 - 193.70 X37 - 200.89 X38 - 209.28 X39 - 215.89 X40 - 226.96 X41 - 236.83 X42 - 241.05 X43 - 247.40 X44 - 253.85 X45 - 263.08 X46 - 266.34 X47 - 268.31 X48 - 268.31 X49 - 265.91 X50 - 258.63 X51 - 247.72 X52 - 212.76 X53 - 175.99 X54 - 184.77 X59 - 184.33 X60 - 186.08 X61 - 188.69 X62 - 193.70 X63 - 200.89 X64 - 209.28 X65 - 215.89 X66 - 226.96 X67 - 236.83 X68 - 241.05 X69 - 247.40 X70 - 253.85 X71 - 263.08 X72 - 266.34 X73 - 268.31 X74 - 268.31 X75 - 265.91 X76 - 258.63 X77 - 247.72 X78 + X139 + X169 + 0.7 X196 + X223 < 0

DMI 3)-247.72 X1 - 212.76 X2 - 175.99 X3 - 186.98 X10 - 188.69 X11 - 193.53 X12 - 200.73 X13 - 209.12 X14 - 215.74 X15 - 226.82 X16 - 236.69 X17 - 240.92 X18 - 247.28 X19 - 253.75 X20 - 262.99 X21 - 266.26 X22 - 268.25 X23 - 268.26 X24 - 265.88 X25 - 258.61 X26 - 247.72 X27 - 212.76 X28 - 175.99 X29 - 184.77 X34 - 184.33 X35 - 186.08 X36 - 188.69 X37 - 193.70 X38 - 200.89 X39 - 209.28 X40 - 215.89 X41 - 226.96 X42 - 236.83 X43 - 241.05 X44 - 247.40 X45 - 253.85 X46 - 263.08 X47 - 266.34 X48 - 268.31 X49 - 268.31 X50 - 265.91 X51 - 258.63 X52 - 247.72 X53 - 212.76 X54 - 175.99 X55 - 184.77 X60 - 184.33 X61- 186.08 X62 - 188.69 X63 - 193.70 X64 - 200.89 X65 - 209.28 X66 - 215.89 X67 - 226.96 X68 - 236.83 X69 - 241.05 X70 - 247.40 X71 - 253.85 X72 - 263.08 X73 - 266.34 X74 - 268.31 X75 - 268.31 X76 - 265.91 X77 - 258.63 X78 + X140 + X170 + 0.7 X197 + X224 < 0

DMI 4)-258.61 X1 - 247.72 X2 - 212.76 X3 - 175.99 X4 - 186.98 X11 - 188.69 X12 - 193.53 X13 - 200.73 X14 - 209.12 X15 - 215.74 X16 - 226.82 X17 - 236.69 X18 - 240.92 X19 - 247.28 X20 - 253.75 X21 - 262.99 X22 - 266.26 X23 - 268.25 X24 - 268.26 X25 - 265.88 X26 - 258.63 X27 - 247.72 X28 - 212.76 X29 - 175.99 X30 - 184.77 X35 - 184.33 X36 - 186.08 X37 - 188.69 X38 - 193.70 X39 - 200.89 X40 - 209.28 X41 - 215.89 X42 - 226.96 X43 - 236.83 X44 - 241.05 X45 - 247.40 X46 - 253.85 X47 - 263.08 X48 - 266.34 X49 - 268.31 X50 - 268.31 X51 - 265.91 X52 - 258.63 X53 - 247.72 X54 - 212.76 X55 - 175.99 X56 - 184.77 X61 - 184.33 X62 - 186.08 X63 - 188.69 X64 - 193.70 X65 - 200.89 X66 - 209.28 X67 - 215.89 X68 - 226.96 X69 - 236.83 X70 - 241.05 X71 - 247.40 X72 - 253.85 X73 - 263.08 X74 - 266.34 X75 - 268.31 X76 - 268.31 X77 - 265.91 X78 + X141 + X171 + 0.7 X198 + X225 < 0

DMI 5)-265.88 X1 - 258.61 X2 - 247.72 X3 - 212.76 X4 - 175.99 X5 - 186.98 X12 - 188.69 X13 - 193.53 X14 - 200.73 X15 - 209.12 X16 - 215.74 X17 - 226.82 X18 - 236.69 X19 - 240.92 X20 - 247.28 X21 - 253.75 X22 - 262.99 X23 - 266.26 X24 - 268.25 X25 - 268.26 X26 - 265.91 X27 - 258.63 X28 - 247.72

X29 - 212.76 X30 - 175.99 X31 - 184.77 X36 - 184.33 X37 - 186.08 X38 - 188.69 X39 - 193.70 X40 - 200.89 X41 - 209.28 X42 - 215.89 X43 - 226.96 X44 - 236.83 X45 - 241.05 X46 - 247.40 X47 - 253.85 X48 - 263.08 X49 - 266.34 X50 - 268.31 X51 - 268.31 X52 - 265.91 X53 - 258.63 X54 - 247.72 X55 - 212.76 X56 - 175.99 X57 - 184.77 X62 - 184.33 X63 - 186.08 X64 - 188.69 X65 - 193.70 X66 - 200.89 X67 - 209.28 X68 - 215.89 X69 - 226.96 X70 - 236.83 X71 - 241.05 X72 - 247.40 X73 - 253.85 X74 - 263.08 X75 - 266.34 X76 - 268.31 X77 - 268.31 X78 + X142 + X172 + 0.7 X199 + X226 < 0

DMI 6)-268.26 X1 - 265.88 X2 - 258.61 X3 - 247.72 X4 - 212.76 X5 - 175.99 X6 - 186.98 X13 - 188.69 X14 - 193.53 X15 - 200.73 X16 - 209.12 X17 - 215.74 X18 - 226.82 X19 - 236.69 X20 - 240.92 X21 - 247.28 X22 - 253.75 X23 - 262.99 X24 - 266.26 X25 - 268.25 X26 - 268.31 X27 - 265.91 X28 - 258.63 X29 - 247.72 X30 - 212.76 X31 - 175.99 X32 - 184.77 X37 - 184.33 X38 - 186.08 X39 - 188.69 X40 - 193.70 X41 - 200.89 X42 - 209.28 X43 - 215.89 X44 - 226.96 X45 - 236.83 X46 - 241.05 X47 - 247.40 X48 - 253.85 X49 - 263.08 X50 - 266.34 X51 - 268.31 X52 - 268.31 X53 - 265.91 X54 - 258.63 X55 - 247.72 X56 - 212.76 X57 - 175.99 X58 - 184.77 X63 - 184.33 X64 - 186.08 X65 - 188.69 X66 - 193.70 X67 - 200.89 X68 - 209.28 X69 - 215.89 X70 - 226.96 X71 - 236.83 X72 - 241.05 X73 - 247.40 X74 - 253.85 X75 - 263.08 X76 - 266.34 X77 - 268.31 X78 + X143 + X173 + 0.7 X200 + X227 < 0

DMI 7)-268.25 X1 - 268.26 X2 - 265.88 X3 - 258.61 X4 - 247.72 X5 - 212.76 X6 - 175.99 X7 - 186.98 X14 - 188.69 X15 - 193.53 X16 - 200.73 X17 - 209.12 X18 - 215.74 X19 - 226.82 X20 - 236.69 X21 - 240.92 X22 - 247.28 X23 - 253.75 X24 - 262.99 X25 - 266.26 X26 - 268.31 X27 - 268.31 X28 - 265.91 X29 - 258.63 X30 - 247.72 X31 - 212.76 X32 - 175.99 X33 - 184.77 X38 - 184.33 X39 - 186.08 X40 - 188.69 X41 - 193.70 X42 - 200.89 X43 - 209.28 X44 - 215.89 X45 - 226.96 X46 - 236.83 X47 - 241.05 X48 - 247.40 X49 - 253.85 X50 - 263.08 X51 - 266.34 X52 - 268.31 X53 - 268.31 X54 - 265.91 X55 - 258.63 X56 - 247.72 X57 - 212.76 X58 - 175.99 X59 - 184.77 X64 - 184.33 X65 - 186.08 X66 - 188.69 X67 - 193.70 X68 - 200.89 X69 - 209.28 X70 - 215.89 X71 - 226.96 X72 - 236.83 X73 - 241.05 X74 - 247.40 X75 - 253.85 X76 - 263.08 X77 - 266.34 X78 + X144 + X174 + 0.7 X201 + X228 < 0

DMI 8)-266.26 X1 - 268.25 X2 - 268.26 X3 - 265.88 X4 - 258.61 X5 - 247.72 X6 - 212.76 X7 - 175.99 X8 - 186.98 X15 - 188.69 X16 - 193.53 X17 - 200.73 X18 - 209.12 X19 - 215.74 X20 - 226.82 X21 - 236.69 X22 - 240.92 X23 - 247.28 X24 - 253.75 X25 - 262.99 X26 - 266.34 X27 - 268.31 X28 - 268.31 X29 - 265.91 X30 - 258.63 X31 - 247.72 X32 - 212.76 X33 - 175.99 X34 - 184.77 X39 - 184.33 X40 - 186.08 X41 - 188.69 X42 - 193.70 X43 - 200.89 X44 - 209.28 X45 - 215.89 X46 - 226.96 X47 - 236.83 X48 - 241.05 X49 - 247.40 X50 - 253.85 X51 - 263.08 X52 - 266.34 X53 - 268.31 X54 - 268.31 X55 - 265.91 X56 - 258.63 X57 - 247.72 X58 - 212.76 X59 - 175.99 X60 - 184.77 X65 - 184.33 X66 - 186.08 X67 - 188.69 X68 - 193.70 X69 - 200.89 X70 - 209.28 X71 - 215.89 X72 - 226.96 X73 - 236.83 X74 - 241.05 X75 - 247.40 X76 - 253.85 X77 - 263.08 X78 + X145 + X175 + 0.7 X202 + X229 < 0

DMI 9)-262.99 X1 - 266.26 X2 - 268.25 X3 - 268.26 X4 - 265.88 X5 - 258.61 X6 - 247.72 X7 - 212.76 X8 - 175.99 X9 - 186.98 X16 - 188.69 X17 - 193.53 X18 - 200.73 X19 - 209.12 X20 - 215.74 X21 - 226.82 X22 - 236.69 X23 - 240.92 X24 - 247.28 X25 - 253.75 X26 - 263.08 X27 - 266.34 X28 - 268.31 X29 - 268.31 X30 - 265.91 X31 - 258.63 X32 - 247.72 X33 - 212.76 X34 - 175.99 X35 - 184.77 X40 - 184.33 X41 - 186.08 X42 - 188.69 X43 - 193.70 X44 - 200.89 X45 - 209.28 X46 - 215.89 X47 - 226.96 X48 - 236.83 X49 - 241.05 X50 - 247.40 X51 - 253.85 X52 - 263.08 X53 - 266.34 X54 - 268.31 X55 - 268.31 X56 - 265.91 X57 - 258.63 X58 - 247.72 X59 - 212.76 X60 - 175.99 X61 - 184.77 X66 - 184.33 X67 - 186.08 X68 - 188.69 X69 - 193.70 X70 - 200.89 X71 - 209.28 X72 - 215.89 X73 - 226.96 X74 - 236.83 X75 - 241.05 X76 - 247.40 X77 - 253.85 X78 + X146 + X176 + 0.7 X203 + X230 < 0

DMI 10) -253.75 X1 - 262.99 X2 - 266.26 X3 - 268.25 X4 - 268.26 X5 - 265.88 X6 - 258.61 X7 - 247.72 X8 - 212.76 X9 - 175.99 X10 - 186.98 X17 - 188.69 X18 - 193.53 X19 - 200.73 X20 - 209.12 X21 - 215.74 X22 - 226.82 X23 - 236.69 X24 - 240.92 X25 - 247.28 X26 - 253.85 X27 - 263.08 X28 - 266.34 X29

- 268.31 X30 - 268.31 X31 - 265.91 X32 - 258.63 X33 - 247.72 X34 - 212.76 X35 - 175.99 X36 - 184.77 X41 - 184.33 X42 - 186.08 X43 - 188.69 X44 - 193.70 X45 - 200.89 X46 - 209.28 X47 - 215.89 X48 - 226.96 X49 - 236.83 X50 - 241.05 X51 - 247.40 X52 - 253.85 X53 - 263.08 X54 - 266.34 X55 - 268.31 X56 - 268.31 X57 - 265.91 X58 - 258.63 X59 - 247.72 X60 - 212.76 X61 - 175.99 X62 - 184.77 X67 - 184.33 X68 - 186.08 X69 - 188.69 X70 - 193.70 X71 - 200.89 X72 - 209.28 X73 - 215.89 X74 - 226.96 X75 - 236.83 X76 - 241.05 X77 - 247.40 X78 + X147 + X177 + 0.7 X204 + X231 < 0

DMI 11) -247.28 X1 - 253.75 X2 - 262.99 X3 - 266.26 X4 - 268.25 X5 - 268.26 X6 - 265.88 X7 - 258.61 X8 - 247.72 X9 - 212.76 X10 - 175.99 X11 - 186.98 X18 - 188.69 X19 - 193.53 X20 - 200.73 X21 - 209.12 X22 - 215.74 X23 - 226.82 X24 - 236.69 X25 - 240.92 X26 - 247.40 X27 - 253.85 X28 - 263.08 X29 - 266.34 X30 - 268.31 X31 - 268.31 X32 - 265.91 X33 - 258.63 X34 - 247.72 X35 - 212.76 X36 - 175.99 X37 - 184.77 X42 - 184.33 X43 - 186.08 X44 - 188.69 X45 - 193.70 X46 - 200.89 X47 - 209.28 X48 - 215.89 X49 - 226.96 X50 - 236.83 X51 - 241.05 X52 - 247.40 X53 - 253.85 X54 - 263.08 X55 - 266.34 X56 - 268.31 X57 - 268.31 X58 - 265.91 X59 - 258.63 X60 - 247.72 X61 - 212.76 X62 - 175.99 X63 - 184.77 X68 - 184.33 X69 - 186.08 X70 - 188.69 X71 - 193.70 X72 - 200.89 X73 - 209.28 X74 - 215.89 X75 - 226.96 X76 - 236.83 X77 - 241.05 X78 + X148 + X178 + 0.7 X205 + X232 < 0

DMI 12) -240.92 X1 - 247.28 X2 - 253.75 X3 - 262.99 X4 - 266.26 X5 - 268.25 X6 - 268.26 X7 - 265.88 X8 - 258.61 X9 - 247.72 X10 - 212.76 X11 - 175.99 X12 - 186.98 X19 - 188.69 X20 - 193.53 X21 - 200.73 X22 - 209.12 X23 - 215.74 X24 - 226.82 X25 - 236.69 X26 - 241.05 X27 - 247.40 X28 - 253.85 X29 - 263.08 X30 - 266.34 X31 - 268.31 X32 - 268.31 X33 - 265.91 X34 - 258.63 X35 - 247.72 X36 - 212.76 X37 - 175.99 X38 - 184.77 X43 - 184.33 X44 - 186.08 X45 - 188.69 X46 - 193.70 X47 - 200.89 X48 - 209.28 X49 - 215.89 X50 - 226.96 X51 - 236.83 X52 - 241.05 X53 - 247.40 X54 - 253.85 X55 - 263.08 X56 - 266.34 X57 - 268.31 X58 - 268.31 X59 - 265.91 X60 - 258.63 X61 - 247.72 X62 - 212.76 X63 - 175.99 X64 - 184.77 X69 - 184.33 X70 - 186.08 X71 - 188.69 X72 - 193.70 X73 - 200.89 X74 - 209.28 X75 - 215.89 X76 - 226.96 X77 - 236.83 X78 + X149 + X179 + 0.7 X206 + X233 < 0

DMI 13) -236.69 X1 - 240.92 X2 - 247.28 X3 - 253.75 X4 - 262.99 X5 - 266.26 X6 - 268.25 X7 - 268.26 X8 - 265.88 X9 - 258.61 X10 - 247.72 X11 - 212.76 X12 - 175.99 X13 - 186.98 X20 - 188.69 X21 - 193.53 X22 - 200.73 X23 - 209.12 X24 - 215.74 X25 - 226.82 X26 - 236.83 X27 - 241.05 X28 - 247.40 X29 - 253.85 X30 - 263.08 X31 - 266.34 X32 - 268.31 X33 - 268.31 X34 - 265.91 X35 - 258.63 X36 - 247.72 X37 - 212.76 X38 - 175.99 X39 - 184.77 X44 - 184.33 X45 - 186.08 X46 - 188.69 X47 - 193.70 X48 - 200.89 X49 - 209.28 X50 - 215.89 X51 - 226.96 X52 - 236.83 X53 - 241.05 X54 - 247.40 X55 - 253.85 X56 - 263.08 X57 - 266.34 X58 - 268.31 X59 - 268.31 X60 - 265.91 X61 - 258.63 X62 - 247.72 X63 - 212.76 X64 - 175.99 X65 - 184.77 X70 - 184.33 X71 - 186.08 X72 - 188.69 X73 - 193.70 X74 - 200.89 X75 - 209.28 X76 - 215.89 X77 - 226.96 X78 + X150 + X180 + 0.7 X207 + X234 < 0

DMI 14) -226.82 X1 - 236.69 X2 - 240.92 X3 - 247.28 X4 - 253.75 X5 - 262.99 X6 - 266.26 X7 - 268.25 X8 - 268.26 X9 - 265.88 X10 - 258.61 X11 - 247.72 X12 - 212.76 X13 - 175.99 X14 - 186.98 X21 - 188.69 X22 - 193.53 X23 - 200.73 X24 - 209.12 X25 - 215.74 X26 - 226.96 X27 - 236.83 X28 - 241.05 X29 - 247.40 X30 - 253.85 X31 - 263.08 X32 - 266.34 X33 - 268.31 X34 - 268.31 X35 - 265.91 X36 - 258.63 X37 - 247.72 X38 - 212.76 X39 - 175.99 X40 - 184.77 X45 - 184.33 X46 - 186.08 X47 - 188.69 X48 - 193.70 X49 - 200.89 X50 - 209.28 X51 - 215.89 X52 - 226.96 X53 - 236.83 X54 - 241.05 X55 - 247.40 X56 - 253.85 X57 - 263.08 X58 - 266.34 X59 - 268.31 X60 - 268.31 X61 - 265.91 X62 - 258.63 X63 - 247.72 X64 - 212.76 X65 - 175.99 X66 - 184.77 X71 - 184.33 X72 - 186.08 X73 - 188.69 X74 - 193.70 X75 - 200.89 X76 - 209.28 X77 - 215.89 X78 + X151 + X181 + 0.7 X208 + X235 < 0

DMI 15) -215.74 X1 - 226.82 X2 - 236.69 X3 - 240.92 X4 - 247.28 X5 - 253.75 X6 - 262.99 X7 - 266.26 X8 - 268.25 X9 - 268.26 X10 - 265.88 X11 - 258.61 X12 - 247.72 X13 - 212.76 X14 - 175.99 X15 - 186.98 X22 - 188.69 X23 - 193.53 X24 - 200.73 X25 - 209.12 X26 - 215.89 X27 - 226.96 X28 - 236.83 X29

- 241.05 X30 - 247.40 X31 - 253.85 X32 - 263.08 X33 - 266.34 X34 - 268.31 X35 - 268.31 X36 - 265.91 X37 - 258.63 X38 - 247.72 X39 - 212.76 X40 - 175.99 X41 - 184.77 X46 - 184.33 X47 - 186.08 X48 - 188.69 X49 - 193.70 X50 - 200.89 X51 - 209.28 X52 - 215.89 X53 - 226.96 X54 - 236.83 X55 - 241.05 X56 - 247.40 X57 - 253.85 X58 - 263.08 X59 - 266.34 X60 - 268.31 X61 - 268.31 X62 - 265.91 X63 - 258.63 X64 - 247.72 X65 - 212.76 X66 - 175.99 X67 - 184.77 X72 - 184.33 X73 - 186.08 X74 - 188.69 X75 - 193.70 X76 - 200.89 X7 - 209.28 X78 + X152 + X182 + 0.7 X209 + X236 < 0

DMI 16) -209.12 X1 - 215.74 X2 - 226.82 X3 - 236.69 X4 - 240.92 X5 - 247.28 X6 - 253.75 X7 - 262.99 X8 - 266.26 X9 - 268.25 X10 - 268.26 X11 - 265.88 X12 - 258.61 X13 - 247.72 X14 - 212.76 X15 - 175.99 X16 - 186.98 X23 - 188.69 X24 - 193.53 X25 - 200.73 X26 - 209.28 X27 - 215.89 X28 - 226.96 X29 - 236.83 X30 - 241.05 X31 - 247.40 X32 - 253.85 X33 - 263.08 X34 - 266.34 X35 - 268.31 X36 - 268.31 X37 - 265.91 X38 - 258.63 X39 - 247.72 X40 - 212.76 X41 - 175.99 X42 - 184.77 X47 - 184.33 X48 - 186.08 X49 - 188.69 X50 - 193.70 X51 - 200.89 X52 - 209.28 X53 - 215.89 X54 - 226.96 X55 - 236.83 X56 - 241.05 X57 - 247.40 X58 - 253.85 X59 - 263.08 X60 - 266.34 X61 - 268.31 X62 - 268.31 X63 - 265.91 X64 - 258.63 X65 - 247.72 X66 - 212.76 X67 - 175.99 X68 - 184.77 X73 - 184.33 X74 - 186.08 X75 - 188.69 X76 - 193.70 X77 - 200.89 X78 + X153 + X183 + 0.7 X210 + X237 < 0

DMI 17) -200.73 X1 - 209.12 X2 - 215.74 X3 - 226.82 X4 - 236.69 X5 - 240.92 X6 - 247.28 X7 - 253.75 X8 - 262.99 X9 - 266.26 X10 - 268.25 X11 - 268.26 X12 - 265.88 X13 - 258.61 X14 - 247.72 X15 - 212.76 X16 - 175.99 X17 - 186.98 X24 - 188.69 X25 - 193.53 X26 - 200.89 X27 - 209.28 X28 - 215.89 X29 - 226.96 X30 - 236.83 X31 - 241.05 X32 - 247.40 X33 - 253.85 X34 - 263.08 X35 - 266.34 X36 - 268.31 X37 - 268.31 X38 - 265.91 X39 - 258.63 X40 - 247.72 X41 - 212.76 X42 - 175.99 X43 - 184.77 X48 - 184.33 X49 - 186.08 X50 - 188.69 X51 - 193.70 X52 - 200.89 X53 - 209.28 X54 - 215.89 X55 - 226.96 X56 - 236.83 X57 - 241.05 X58 - 247.40 X59 - 253.85 X60 - 263.08 X61 - 266.34 X62 - 268.31 X63 - 268.31 X64 - 265.91 X65 - 258.63 X66 - 247.72 X67 - 212.76 X68 - 175.99 X69 - 184.77 X74 - 184.33 X75 - 186.08 X76 - 188.69 X77 - 193.70 X78 + X154 + X184 + 0.7 X211 + X238 < 0

DMI 18) -193.53 X1 - 200.73 X2 - 209.12 X3 - 215.74 X4 - 226.82 X5 - 236.69 X6 - 240.92 X7 - 247.28 X8 - 253.75 X9 - 262.99 X10 - 266.26 X11 - 268.25 X12 - 268.26 X13 - 265.88 X14 - 258.61 X15 - 247.72 X16 - 212.76 X17 - 175.99 X18 - 186.98 X25 - 188.69 X26 - 193.70 X27 - 200.89 X28 - 209.28 X29 - 215.89 X30 - 226.96 X31 - 236.83 X32 - 241.05 X33 - 247.40 X34 - 253.85 X35 - 263.08 X36 - 266.34 X37 - 268.31 X38 - 268.31 X39 - 265.91 X40 - 258.63 X41 - 247.72 X42 - 212.76 X43 - 175.99 X44 - 184.77 X49 - 184.33 X50 - 186.08 X51 - 188.69 X52 - 193.70 X53 - 200.89 X54 - 209.28 X55 - 215.89 X56 - 226.96 X57 - 236.83 X58 - 241.05 X59 - 247.40 X60 - 253.85 X61 - 263.08 X62 - 266.34 X63 - 268.31 X64 - 268.31 X65 - 265.91 X66 - 258.63 X67 - 247.72 X68 - 212.76 X69 - 175.99 X70 - 184.77 X75 - 184.33 X76 - 186.08 X77 - 188.69 X78 + X155 + X185 + 0.7 X212 + X239 < 0

DMI 19) -188.69 X1 - 193.53 X2 - 200.73 X3 - 209.12 X4 - 215.74 X5 - 226.82 X6 - 236.69 X7 - 240.92 X8 - 247.28 X9 - 253.75 X10 - 262.99 X11 - 266.26 X12 - 268.25 X13 - 268.26 X14 - 265.88 X15 - 258.61 X16 - 247.72 X17 - 212.76 X18 - 175.99 X19 - 186.98 X26 - 188.69 X27 - 193.70 X28 - 200.89 X29 - 209.28 X30 - 215.89 X31 - 226.96 X32 - 236.83 X33 - 241.05 X34 - 247.40 X35 - 253.85 X36 - 263.08 X37 - 266.34 X38 - 268.31 X39 - 268.31 X40 - 265.91 X41 - 258.63 X42 - 247.72 X43 - 212.76 X44 - 175.99 X45 - 184.77 X50 - 184.33 X51 - 186.08 X52 - 188.69 X53 - 193.70 X54 - 200.89 X55 - 209.28 X56 - 215.89 X57 - 226.96 X58 - 236.83 X59 - 241.05 X60 - 247.40 X61 - 253.85 X62 - 263.08 X63 - 266.34 X64 - 268.31 X65 - 268.31 X66 - 265.91 X67 - 258.63 X68 - 247.72 X69 - 212.76 X70 - 175.99 X71 - 184.77 X76 - 184.33 X77 - 186.08 X78 + X156 + X186 + 0.7 X213 + X240 < 0

DMI 20) -186.98 X1 - 188.69 X2 - 193.53 X3 - 200.73 X4 - 209.12 X5 - 215.74 X6 - 226.82 X7 - 236.69 X8 - 240.92 X9 - 247.28 X10 - 253.75 X11 - 262.99 X12 - 266.26 X13 - 268.25 X14 - 268.26 X15 - 265.88 X16 - 258.61 X17 - 247.72 X18 - 212.76 X19 - 175.99 X20 - 186.08 X27 - 188.69 X28 - 193.70 X29

- 200.89 X30 - 209.28 X31 - 215.89 X32 - 226.96 X33 - 236.83 X34 - 241.05 X35 - 247.40 X36 - 253.85 X37 - 263.08 X38 - 266.34 X39 - 268.31 X40 - 268.31 X41 - 265.91 X42 - 258.63 X43 - 247.72 X44 - 212.76 X45 - 175.99 X46 - 184.77 X51 - 184.33 X52 - 186.08 X53 - 188.69 X54 - 193.70 X55 - 200.89 X56 - 209.28 X57 - 215.89 X58 - 226.96 X59 - 236.83 X60 - 241.05 X61 - 247.40 X62 - 253.85 X63 - 263.08 X64 - 266.34 X65 - 268.31 X66 - 268.31 X67 - 265.91 X68 - 258.63 X69 - 247.72 X70 - 212.76 X71 - 175.99 X72 - 184.77 X77 - 184.33 X78 + X157 + X187 + 0.7 X214 + X241 < 0

DMI 21) - 186.98 X2 - 188.69 X3 - 193.53 X4 - 200.73 X5 - 209.12 X6 - 215.74 X7 - 226.82 X8 - 236.69 X9 - 240.92 X10 - 247.28 X11 - 253.75 X12 - 262.99 X13 - 266.26 X14 - 268.25 X15 - 268.26 X16 - 265.88 X17 - 258.61 X18 - 247.72 X19 - 212.76 X20 - 175.99 X21 - 184.33 X27 - 186.08 X28 - 188.69 X29 - 193.70 X30 - 200.89 X31 - 209.28 X32 - 215.89 X33 - 226.96 X34 - 236.83 X35 - 241.05 X36 - 247.40 X37 - 253.85 X38 - 263.08 X39 - 266.34 X40 - 268.31 X41 - 268.31 X42 - 265.91 X43 - 258.63 X44 - 247.72 X45 - 212.76 X46 - 175.99 X47 - 184.77 X52 - 184.33 X53 - 186.08 X54 - 188.69 X55 - 193.70 X56 - 200.89 X57 - 209.28 X58 - 215.89 X59 - 226.96 X60 - 236.83 X61 - 241.05 X62 - 247.40 X63 - 253.85 X64 - 263.08 X65 - 266.34 X66 - 268.31 X67 - 268.31 X68 - 265.91 X69 - 258.63 X70 - 247.72 X71 - 212.76 X72 - 175.99 X73 - 184.77 X78 + X158 + X188 + 0.7 X215 + X242 < 0

DMI 22) - 186.98 X3 - 188.69 X4 - 193.53 X5 - 200.73 X6 - 209.12 X7 - 215.74 X8 - 226.82 X9 - 236.69 X10 - 240.92 X11 - 247.28 X12 - 253.75 X13 - 262.99 X14 - 266.26 X15 - 268.25 X16 - 268.26 X17 - 265.88 X18 - 258.61 X19 - 247.72 X20 - 212.76 X21 - 175.99 X22 - 184.77 X27 - 184.33 X28 - 186.08 X29 - 188.69 X30 - 193.70 X31 - 200.89 X32 - 209.28 X33 - 215.89 X34 - 226.96 X35 - 236.83 X36 - 241.05 X37 - 247.40 X38 - 253.85 X39 - 263.08 X40 - 266.34 X41 - 268.31 X42 - 268.31 X43 - 265.91 X44 - 258.63 X45 - 247.72 X46 - 212.76 X47 - 175.99 X48 - 184.77 X53 - 184.33 X54 - 186.08 X55 - 188.69 X56 - 193.70 X57 - 200.89 X58 - 209.28 X59 - 215.89 X60 - 226.96 X61 - 236.83 X62 - 241.05 X63 - 247.40 X64 - 253.85 X65 - 263.08 X66 - 266.34 X67 - 268.31 X68 - 268.31 X69 - 265.91 X70 - 258.63 X71 - 247.72 X72 - 212.76 X73 - 175.99 X74 + X159 + X189 + 0.7 X216 + X243 < 0

DMI 23) - 186.98 X4 - 188.69 X5 - 193.53 X6 - 200.73 X7 - 209.12 X8 - 215.74 X9 - 226.82 X10 - 236.69 X11 - 240.92 X12 - 247.28 X13 - 253.75 X14 - 262.99 X15 - 266.26 X16 - 268.25 X17 - 268.26 X18 - 265.88 X19 - 258.61 X20 - 247.72 X21 - 212.76 X22 - 175.99 X23 - 184.77 X28 - 184.33 X29 - 186.08 X30 - 188.69 X31 - 193.70 X32 - 200.89 X33 - 209.28 X34 - 215.89 X35 - 226.96 X36 - 236.83 X37 - 241.05 X38 - 247.40 X39 - 253.85 X40 - 263.08 X41 - 266.34 X42 - 268.31 X43 - 268.31 X44 - 265.91 X45 - 258.63 X46 - 247.72 X47 - 212.76 X48 - 175.99 X49 - 184.77 X54 - 184.33 X55 - 186.08 X56 - 188.69 X57 - 193.70 X58 - 200.89 X59 - 209.28 X60 - 215.89 X61 - 226.96 X62 - 236.83 X63 - 241.05 X64 - 247.40 X65 - 253.85 X66 - 263.08 X67 - 266.34 X68 - 268.31 X69 - 268.31 X70 - 265.91 X71 - 258.63 X72 - 247.72 X73 - 212.76 X74 - 175.99 X75 + X160 + X190 + 0.7 X217 + X244 < 0

DMI 24) - 186.98 X5 - 188.69 X6 - 193.53 X7 - 200.73 X8 - 209.12 X9 - 215.74 X10 - 226.82 X11 - 236.69 X12 - 240.92 X13 - 247.28 X14 - 253.75 X15 - 262.99 X16 - 266.26 X17 - 268.25 X18 - 268.26 X19 - 265.88 X20 - 258.61 X21 - 247.72 X22 - 212.76 X23 - 175.99 X24 - 184.77 X29 - 184.33 X30 - 186.08 X31 - 188.69 X32 - 193.70 X33 - 200.89 X34 - 209.28 X35 - 215.89 X36 - 226.96 X37 - 236.83 X38 - 241.05 X39 - 247.40 X40 - 253.85 X41 - 263.08 X42 - 266.34 X43 - 268.31 X44 - 268.31 X45 - 265.91 X46 - 258.63 X47 - 247.72 X48 - 212.76 X49 - 175.99 X50 - 184.77 X55 - 184.33 X56 - 186.08 X57 - 188.69 X58 - 193.70 X59 - 200.89 X60 - 209.28 X61 - 215.89 X62 - 226.96 X63 - 236.83 X64 - 241.05 X65 - 247.40 X66 - 253.85 X67 - 263.08 X68 - 266.34 X69 - 268.31 X70 - 268.31 X71 - 265.91 X72 - 258.63 X73 - 247.72 X74 - 212.76 X75 - 175.99 X76 + X161 + X191 + 0.7 X218 + X245 < 0

DMI 25) - 186.98 X6 - 188.69 X7 - 193.53 X8 - 200.73 X9 - 209.12 X10 - 215.74 X11 - 226.82 X12 - 236.69 X13 - 240.92 X14 - 247.28 X15 - 253.75 X16 - 262.99 X17 - 266.26 X18 - 268.25 X19 - 268.26 X20 - 265.88 X21 - 258.61 X22 - 247.72 X23 - 212.76 X24 - 175.99 X25 - 184.77 X30 - 184.33 X31 -

186.08 X32 - 188.69 X33 - 193.70 X34 - 200.89 X35 - 209.28 X36 - 215.89 X37 - 226.96 X38 - 236.83 X39 - 241.05 X40 - 247.40 X41 - 253.85 X42 - 263.08 X43 - 266.34 X44 - 268.31 X45 - 268.31 X46 - 265.91 X47 - 258.63 X48 - 247.72 X49 - 212.76 X50 - 175.99 X51 - 184.77 X56 - 184.33 X57 - 186.08 X58 - 188.69 X59 - 193.70 X60 - 200.89 X61 - 209.28 X62 - 215.89 X63 - 226.96 X64 - 236.83 X65 - 241.05 X66 - 247.40 X67 - 253.85 X68 - 263.08 X69 - 266.34 X70 - 268.31 X71 - 268.31 X72 - 265.91 X73 - 258.63 X74 - 247.72 X75 - 212.76 X76 - 175.99 X77 + X162 + X192 + 0.7 X219 + X246 < 0

DMI 26) - 186.98 X7 - 188.69 X8 - 193.53 X9 - 200.73 X10 - 209.12 X11 - 215.74 X12 - 226.82 X13 - 236.69 X14 - 240.92 X15 - 247.28 X16 - 253.75 X17 - 262.99 X18 - 266.26 X19 - 268.25 X20 - 268.26 X21 - 265.88 X22 - 258.61 X23 - 247.72 X24 - 212.76 X25 - 175.99 X26 - 184.77 X31 - 184.33 X32 - 186.08 X33 - 188.69 X34 - 193.70 X35 - 200.89 X36 - 209.28 X37 - 215.89 X38 - 226.96 X39 - 236.83 X40 - 241.05 X41 - 247.40 X42 - 253.85 X43 - 263.08 X44 - 266.34 X45 - 268.31 X46 - 268.31 X47 - 265.91 X48 - 258.63 X49 - 247.72 X50 - 212.76 X51 - 175.99 X52 - 184.77 X57 - 184.33 X58 - 186.08 X59 - 188.69 X60 - 193.70 X61 - 200.89 X62 - 209.28 X63 - 215.89 X64 - 226.96 X65 - 236.83 X66 - 241.05 X67 - 247.40 X68 - 253.85 X69 - 263.08 X70 - 266.34 X71 - 268.31 X72 - 268.31 X73 - 265.91 X74 - 258.63 X75 - 247.72 X76 - 212.76 X77 - 175.99 X78 + X163 + X193 + 0.7 X220 + X247 < 0

COWME01) 2007.86 X1 + 1626.16 X8 + 2031.90 X9 + 1996.42 X10 + 1965.05 X11 + 1963.04 X12 + 1980.53 X13 + 2026.04 X14 + 2053.97 X15 + 2103.07 X16 + 2148.27 X17 + 2194.89 X18 + 2247.07 X19 + 2289.57 X20 + 2342.07 X21 + 2387.06 X22 + 2425.05 X23 + 2424.17 X24 + 2349.71 X25 + 2235.80 X26 + 2026.51 X27 + 0.00 X28 + 0.00 X29 + 0.00 X30 + 0.00 X31 + 1142.49 X32 + 2043.28 X33 + 1992.10 X34 + 1986.80 X35 + 2010.46 X36 + 1979.77 X37 + 1978.38 X38 + 1996.37 X39 + 2042.77 X40 + 2071.21 X41 + 2121.28 X42 + 2167.14 X43 + 2214.61 X44 + 2267.44 X45 + 2310.68 X46 + 2363.74 X47 + 2409.37 X48 + 2447.87 X49 + 2446.99 X50 + 2372.20 X51 + 2257.29 X52 + 2245 X53 + 0.00 X54 + 0.00 X55 + 0.00 X56 + 0.00 X57 + 1235 X58 + 2216 X59 + 2166 X60 + 2254 X61 + 2192 X62 + 2164 X63 + 2167 X64 + 2189 X65 + 2242 X66 + 2277 X67 + 2334 X68 + 2387 X69 + 2442 X70 + 2502 X71 + 2552 X72 + 2612 X73 + 2664 X74 + 2822 X75 + 2822 X76 + 2629 X77 + 2525 X78 - 11.5 X138 - 10.5 X168 - 12.5 X195 - 9.5 X222 < 0

COWME02) 2235.80 X1 + 2007.86 X2 + 1626.16 X9 + 2031.90 X10 + 1996.42 X11 + 1965.05 X12 + 1963.04 X13 + 1980.53 X14 + 2026.04 X15 + 2053.97 X16 + 2103.07 X17 + 2148.27 X18 + 2194.89 X19 + 2247.07 X20 + 2289.57 X21 + 2342.07 X22 + 2387.06 X23 + 2425.05 X24 + 2424.17 X25 + 2349.71 X26 + 2167.29 X27 + 2026.51 X28 + 0.00 X29 + 0.00 X30 + 0.00 X31 + 0.00 X32 + 1142.49 X33 + 2043.28 X34 + 1992.10 X35 + 1986.80 X36 + 2010.46 X37 + 1979.77 X38 + 1978.38 X39 + 1996.37 X40 + 2042.77 X41 + 2071.21 X42 + 2121.28 X43 + 2167.14 X44 + 2214.61 X45 + 2267.44 X46 + 2310.68 X47 + 2363.74 X48 + 2409.37 X49 + 2447.87 X50 + 2446.99 X51 + 2277.20 X52 + 2525 X53 + 2245 X54 + 0.00 X55 + 0.00 X56 + 0.00 X57 + 0.00 X58 + 1235 X59 + 2216 X60 + 2166 X61 + 2164 X62 + 2192 X63 + 2164 X64 + 2167 X65 + 2189 X66 + 2242 X67 + 2277 X68 + 2334 X69 + 2387 X70 + 2442 X71 + 2502 X72 + 2552 X73 + 2612 X74 + 2664 X75 + 2822 X76 + 2822 X77 + 2629 X78 - 11.5 X139 - 10.5 X169 - 12.5 X196 - 9.5 X223 < 0

COWME03) 2349.71 X1 + 2235.80 X2 + 2007.86 X3 + 1626.16 X10 + 2031.90 X11 + 1996.42 X12 + 1965.05 X13 + 1963.04 X14 + 1980.53 X15 + 2026.04 X16 + 2053.97 X17 + 2103.07 X18 + 2148.27 X19 + 2194.89 X20 + 2247.07 X21 + 2289.57 X22 + 2342.07 X23 + 2387.06 X24 + 2425.05 X25 + 2424.17 X26 + 2277.20 X27 + 2167.29 X28 + 2026.51 X29 + 0.00 X30 + 0.00 X31 + 0.00 X32 + 0.00 X33 + 1142.49 X34 + 2043.28 X35 + 1992.10 X36 + 1986.80 X37 + 2010.46 X38 + 1979.77 X39 + 1978.38 X40 + 1996.37 X41 + 2042.77 X42 + 2071.21 X43 + 2121.28 X44 + 2167.14 X45 + 2214.61 X46 + 2267.44 X47 + 2310.68 X48 + 2363.74 X49 + 2409.37 X50 + 2447.87 X51 + 2446.99 X52 + 2629 X53 + 2525 X54 + 2245 X55 + 0.00 X56 + 0.00 X57 + 0.00 X58 + 0.00 X59 + 1235 X60 + 2216 X61 + 2166 X62 + 2164 X63 + 2192 X64 + 2164 X65 + 2167 X66 + 2189 X67 + 2242 X68 + 2277 X69 + 2334 X70 + 2387 X71 + 2442 X72 + 2502 X73 + 2552 X74

+ 2612 X75 + 2664 X76 + 2822 X77 + 2822 X78 - 11.5 X140 - 10.5 X170 - 12.5 X197 - 9.5 X224 < 0

COWME04) 2424.17 X1 + 2349.71 X2 + 2235.80 X3 + 2007.86 X4 + 1626.16 X11 + 2031.90 X12 + 1996.42 X13 + 1965.05 X14 + 1963.04 X15 + 1980.53 X16 + 2026.04 X17 + 2053.97 X18 + 2103.07 X19 + 2148.27 X20 + 2194.89 X21 + 2247.07 X22 + 2289.57 X23 + 2342.07 X24 + 2387.06 X25 + 2425.05 X26 + 2446.99 X27 + 2277.20 X28 + 2167.29 X29 + 2026.51 X30 + 0.00 X31 + 0.00 X32 + 0.00 X33 + 0.00 X34 + 1142.49 X35 + 2043.28 X36 + 1992.10 X37 + 1986.80 X38 + 2010.46 X39 + 1979.77 X40 + 1978.38 X41 + 1996.37 X42 + 2042.77 X43 + 2071.21 X44 + 2121.28 X45 + 2167.14 X46 + 2214.61 X47 + 2267.44 X48 + 2310.68 X49 + 2363.74 X50 + 2409.37 X51 + 2447.87 X52 + 2709 X53 + 2629 X54 + 2525 X55 + 2245 X56 + 0.00 X57 + 0.00 X58 + 0.00 X59 + 0.00 X60 + 1235 X61 + 2216 X62 + 2166 X63 + 2164 X64 + 2192 X65 + 2164 X66 + 2167 X67 + 2189 X68 + 2242 X69 + 2277 X70 + 2334 X71 + 2387 X72 + 2442 X73 + 2502 X74 + 2552 X75 + 2612 X76 + 2664 X77 + 2709 X78 - 11.5 X141 - 10.5 X171 - 12.5 X198 - 9.5 X225 < 0

COWME05) 2425.05 X1 + 2424.17 X2 + 2349.71 X3 + 2235.80 X4 + 2007.86 X5 + 1626.16 X12 + 2031.90 X13 + 1996.42 X14 + 1965.05 X15 + 1963.04 X16 + 1980.53 X17 + 2026.04 X18 + 2053.97 X19 + 2103.07 X20 + 2148.27 X21 + 2194.89 X22 + 2247.07 X23 + 2289.57 X24 + 2342.07 X25 + 2387.06 X26 + 2447.87 X27 + 2446.99 X28 + 2277.20 X29 + 2167.29 X30 + 2026.51 X31 + 0.00 X32 + 0.00 X33 + 0.00 X34 + 0.00 X35 + 1142.49 X36 + 2043.28 X37 + 1992.10 X38 + 1986.80 X39 + 2010.46 X40 + 1979.77 X41 + 1978.38 X42 + 1996.37 X43 + 2042.77 X44 + 2071.21 X45 + 2121.28 X46 + 2167.14 X47 + 2214.61 X48 + 2267.44 X49 + 2310.68 X50 + 2363.74 X51 + 2409.37 X52 + 2709 X53 + 2709 X54 + 2629 X55 + 2525 X56 + 2245 X57 + 0.00 X58 + 0.00 X59 + 0.00 X60 + 0.00 X61 + 1235 X62 + 2216 X63 + 2166 X64 + 2164 X65 + 2192 X66 + 2164 X67 + 2167 X68 + 2189 X69 + 2242 X70 + 2277 X71 + 2334 X72 + 2387 X73 + 2442 X74 + 2502 X75 + 2552 X76 + 2612 X77 + 2664 X78 - 12.0 X142 - 10.5 X172 - 12.5 X199 - 9.5 X226 < 0

COWME06) 2387.06 X1 + 2425.05 X2 + 2424.17 X3 + 2349.71 X4 + 2235.80 X5 + 2007.86 X6 + 1626.16 X13 + 2031.90 X14 + 1996.42 X15 + 1965.05 X16 + 1963.04 X17 + 1980.53 X18 + 2026.04 X19 + 2053.97 X20 + 2103.07 X21 + 2148.27 X22 + 2194.89 X23 + 2247.07 X24 + 2289.57 X25 + 2342.07 X26 + 2409.37 X27 + 2447.87 X28 + 2446.99 X29 + 2277.20 X30 + 2167.29 X31 + 2026.51 X32 + 0.00 X33 + 0.00 X34 + 0.00 X35 + 0.00 X36 + 1142.49 X37 + 2043.28 X38 + 1992.10 X39 + 1986.80 X40 + 2010.46 X41 + 1979.77 X42 + 1978.38 X43 + 1996.37 X44 + 2042.77 X45 + 2071.21 X46 + 2121.28 X47 + 2167.14 X48 + 2214.61 X49 + 2267.44 X50 + 2310.68 X51 + 2363.74 X52 + 2664 X53 + 2709 X54 + 2709 X55 + 2629 X56 + 2525 X57 + 2245 X58 + 0.00 X59 + 0.00 X60 + 0.00 X61 + 0.00 X62 + 1235 X63 + 2216 X64 + 2166 X65 + 2164 X66 + 2192 X67 + 2164 X68 + 2167 X69 + 2189 X70 + 2242 X71 + 2277 X72 + 2334 X73 + 2387 X74 + 2442 X75 + 2502 X76 + 2552 X77 + 2612 X78 - 12.0 X143 - 10.5 X173 - 12.5 X200 - 9.5 X227 < 0

COWME07) 2342.07 X1 + 2387.06 X2 + 2425.05 X3 + 2424.17 X4 + 2349.71 X5 + 2235.80 X6 + 2007.86 X7 + 1626.16 X14 + 2031.90 X15 + 1996.42 X16 + 1965.05 X17 + 1963.04 X18 + 1980.53 X19 + 2026.04 X20 + 2053.97 X21 + 2103.07 X22 + 2148.27 X23 + 2194.89 X24 + 2247.07 X25 + 2289.57 X26 + 2363.74 X27 + 2409.37 X28 + 2447.87 X29 + 2446.99 X30 + 2277.20 X31 + 2167.29 X32 + 2026.51 X33 + 0.00 X34 + 0.00 X35 + 0.00 X36 + 0.00 X37 + 1142.49 X38 + 2043.28 X39 + 1992.10 X40 + 1986.80 X41 + 2010.46 X42 + 1979.77 X43 + 1978.38 X44 + 1996.37 X45 + 2042.77 X46 + 2071.21 X47 + 2121.28 X48 + 2167.14 X49 + 2214.61 X50 + 2267.44 X51 + 2310.68 X52 + 2612 X53 + 2664 X54 + 2709 X55 + 2709 X56 + 2629 X57 + 2525 X58 + 2245 X59 + 0.00 X60 + 0.00 X61 + 0.00 X62 + 0.00 X63 + 1235 X64 + 2216 X65 + 2166 X66 + 2164 X67 + 2192 X68 + 2164 X69 + 2167 X70 + 2189 X71 + 2242 X72 + 2277 X73 + 2334 X74 + 2387 X75 + 2442 X76 + 2502 X77 + 2552 X78 - 12.0 X144 - 10.5 X174 - 12.5 X201 - 9.5 X228 < 0

COWME08) 2289.57 X1 + 2342.07 X2 + 2387.06 X3 + 2425.05 X4 + 2424.17 X5 + 2349.71 X6 + 2235.80 X7 + 2007.86 X8 + 1626.16 X15 + 2031.90 X16 + 1996.42 X17 + 1965.05 X18 + 1963.04 X19 + 1980.53 X20 + 2026.04 X21 + 2053.97 X22 + 2103.07 X23 + 2148.27 X24 + 2194.89 X25 + 2247.07 X26 + 2310.68 X27 + 2363.74 X28 + 2409.37 X29 + 2447.87 X30 + 2446.99 X31 + 2277.20 X32 + 2167.29 X33 + 2026.51 X34 + 0.00 X35 + 0.00 X36 + 0.00 X37 + 0.00 X38 + 1142.49 X39 + 2043.28 X40 + 1992.10 X41 + 1986.80 X42 + 2010.46 X43 + 1979.77 X44 + 1978.38 X45 + 1996.37 X46 + 2042.77 X47 + 2071.21 X48 + 2121.28 X49 + 2167.14 X50 + 2214.61 X51 + 2267.44 X52 + 2552 X53 + 2612 X54 + 2664 X55 + 2709 X56 + 2709 X57 + 2629 X58 + 2525 X59 + 2245 X60 + 0.00 X61 + 0.00 X62 + 0.00 X63 + 0.00 X64 + 1235 X65 + 2216 X66 + 2166 X67 + 2164 X68 + 2192 X69 + 2164 X70 + 2167 X71 + 2189 X72 + 2242 X73 + 2277 X74 + 2334 X75 + 2387 X76 + 2442 X77 + 2502 X78 - 11.5 X145 - 10.5 X175 - 12.5 X202 - 9.5 X229 < 0

COWME09) 2247.07 X1 + 2289.57 X2 + 2342.07 X3 + 2387.06 X4 + 2425.05 X5 + 2424.17 X6 + 2349.71 X7 + 2235.80 X8 + 2007.86 X9 + 1626.16 X16 + 2031.90 X17 + 1996.42 X18 + 1965.05 X19 + 1963.04 X20 + 1980.53 X21 + 2026.04 X22 + 2053.97 X23 + 2103.07 X24 + 2148.27 X25 + 2194.89 X26 + 2267.44 X27 + 2310.68 X28 + 2363.74 X29 + 2409.37 X30 + 2447.87 X31 + 2446.99 X32 + 2277.20 X33 + 2167.29 X34 + 2026.51 X35 + 0.00 X36 + 0.00 X37 + 0.00 X38 + 0.00 X39 + 1142.49 X40 + 2043.28 X41 + 1992.10 X42 + 1986.80 X43 + 2010.46 X44 + 1979.77 X45 + 1978.38 X46 + 1996.37 X47 + 2042.77 X48 + 2071.21 X49 + 2121.28 X50 + 2167.14 X51 + 2214.61 X52 + 2502 X53 + 2552 X54 + 2612 X55 + 2664 X56 + 2709 X57 + 2709 X58 + 2629 X59 + 2525 X60 + 2245 X61 + 0.00 X62 + 0.00 X63 + 0.00 X64 + 0.00 X65 + 1235 X66 + 2216 X67 + 2166 X68 + 2164 X69 + 2192 X70 + 2164 X71 + 2167 X72 + 2189 X73 + 2242 X74 + 2277 X75 + 2334 X76 + 2387 X77 + 2442 X78 - 11.2 X146 - 10.5 X176 - 12.5 X203 - 9.5 X230 < 0

COWME10) 2194.89 X1 + 2247.07 X2 + 2289.57 X3 + 2342.07 X4 + 2387.06 X5 + 2425.05 X6 + 2424.17 X7 + 2349.71 X8 + 2235.80 X9 + 2007.86 X10 + 1626.16 X17 + 2031.90 X18 + 1996.42 X19 + 1965.05 X20 + 1963.04 X21 + 1980.53 X22 + 2026.04 X23 + 2053.97 X24 + 2103.07 X25 + 2148.27 X26 + 2214.61 X27 + 2267.44 X28 + 2310.68 X29 + 2363.74 X30 + 2409.37 X31 + 2447.87 X32 + 2446.99 X33 + 2277.20 X34 + 2167.29 X35 + 2026.51 X36 + 0.00 X37 + 0.00 X38 + 0.00 X39 + 0.00 X40 + 1142.49 X41 + 2043.28 X42 + 1992.10 X43 + 1986.80 X44 + 2010.46 X45 + 1979.77 X46 + 1978.38 X47 + 1996.37 X48 + 2042.77 X49 + 2071.21 X50 + 2121.28 X51 + 2167.14 X52 + 2442 X53 + 2502 X54 + 2552 X55 + 2612 X56 + 2664 X57 + 2709 X58 + 2709 X59 + 2629 X60 + 2525 X61 + 2245 X62 + 0.00 X63 + 0.00 X64 + 0.00 X65 + 0.00 X66 + 1235 X67 + 2216 X68 + 2166 X69 + 2164 X70 + 2192 X71 + 2164 X72 + 2167 X73 + 2189 X74 + 2242 X75 + 2277 X76 + 2334 X77 + 2387 X78 - 11.0 X147 - 10.5 X177 - 12.5 X204 - 9.5 X231 < 0

COWME11) 2148.27 X1 + 2194.89 X2 + 2247.07 X3 + 2289.57 X4 + 2342.07 X5 + 2387.06 X6 + 2425.05 X7 + 2424.17 X8 + 2349.71 X9 + 2235.80 X10 + 2007.86 X11 + 1626.16 X18 + 2031.90 X19 + 1996.42 X20 + 1965.05 X21 + 1963.04 X22 + 1980.53 X23 + 2026.04 X24 + 2053.97 X25 + 2103.07 X26 + 2167.14 X27 + 2214.61 X28 + 2267.44 X29 + 2310.68 X30 + 2363.74 X31 + 2409.37 X32 + 2447.87 X33 + 2446.99 X34 + 2277.20 X35 + 2167.29 X36 + 2026.51 X37 + 0.00 X38 + 0.00 X39 + 0.00 X40 + 0.00 X41 + 1142.49 X42 + 2043.28 X43 + 1992.10 X44 + 1986.80 X45 + 2010.46 X46 + 1979.77 X47 + 1978.38 X48 + 1996.37 X49 + 2042.77 X50 + 2071.21 X51 + 2121.28 X52 + 2387 X53 + 2442 X54 + 2502 X55 + 2552 X56 + 2612 X57 + 2664 X58 + 2709 X59 + 2709 X60 + 2629 X61 + 2525 X62 + 2245 X63 + 0.00 X64 + 0.00 X65 + 0.00 X66 + 0.00 X67 + 1235 X68 + 2216 X69 + 2166 X70 + 2164 X71 + 2192 X72 + 2164 X73 + 2167 X74 + 2189 X75 + 2242 X76 + 2277 X77 + 2334 X78 - 11.0 X148 - 10.5 X178 - 12.5 X205 - 9.5 X232 < 0

COWME12) 2103.07 X1 + 2148.27 X2 + 2194.89 X3 + 2247.07 X4 + 2289.57 X5 + 2342.07 X6 + 2387.06 X7 + 2425.05 X8 + 2424.17 X9 + 2349.71 X10 + 2235.80 X11 + 2007.86 X12 + 1626.16 X19 + 2031.90 X20 + 1996.42 X21 + 1965.05 X22 + 1963.04 X23 + 1980.53 X24 + 2026.04 X25 + 2053.97 X26 + 2121.28 X27 +

2167.14 X28 + 2214.61 X29 + 2267.44 X30 + 2310.68 X31 + 2363.74 X32 + 2409.37 X33 + 2447.87 X34 + 2446.99 X35 + 2277.20 X36 + 2167.29 X37 + 2026.51 X38 + 0.00 X39 + 0.00 X40 + 0.00 X41 + 0.00 X42 + 1142.49 X43 + 2043.28 X44 + 1992.10 X45 + 1986.80 X46 + 2010.46 X47 + 1979.77 X48 + 1978.38 X49 + 1996.37 X50 + 2042.77 X51 + 2071.21 X52 + 2334 X53 + 2387 X54 + 2442 X55 + 2502 X56 + 2552 X57 + 2612 X58 + 2664 X59 + 2709 X60 + 2709 X61 + 2629 X62 + 2525 X63 + 2245 X64 + 0.00 X65 + 0.00 X66 + 0.00 X67 + 0.00 X68 + 1235 X69 + 2216 X70 + 2166 X71 + 2164 X72 + 2192 X73 + 2164 X74 + 2167 X75 + 2189 X76 + 2242 X77 + 2277 X78 - 10.8 X149 - 10.5 X179 - 12.5 X206 - 9.5 X233 < 0

COWME13) 2053.97 X1 + 2103.07 X2 + 2148.27 X3 + 2194.89 X4 + 2247.07 X5 + 2289.57 X6 + 2342.07 X7 + 2387.06 X8 + 2425.05 X9 + 2424.17 X10 + 2349.71 X11 + 2235.80 X12 + 2007.86 X13 + 1626.16 X20 + 2031.90 X21 + 1996.42 X22 + 1965.05 X23 + 1963.04 X24 + 1980.53 X25 + 2026.04 X26 + 2071.21 X27 + 2121.28 X28 + 2167.14 X29 + 2214.61 X30 + 2267.44 X31 + 2310.68 X32 + 2363.74 X33 + 2409.37 X34 + 2447.87 X35 + 2446.99 X36 + 2277.20 X37 + 2167.29 X38 + 2026.51 X39 + 0.00 X40 + 0.00 X41 + 0.00 X42 + 0.00 X43 + 1142.49 X44 + 2043.28 X45 + 1992.10 X46 + 1986.80 X47 + 2010.46 X48 + 1979.77 X49 + 1978.38 X50 + 1996.37 X51 + 2042.77 X52 + 2277 X53 + 2334 X54 + 2387 X55 + 2442 X56 + 2502 X57 + 2552 X58 + 2612 X59 + 2664 X60 + 2709 X61 + 2709 X62 + 2629 X63 + 2525 X64 + 2245 X65 + 0.00 X66 + 0.00 X67 + 0.00 X68 + 0.00 X69 + 1235 X70 + 2216 X71 + 2166 X72 + 2164 X73 + 2192 X74 + 2164 X75 + 2167 X76 + 2189 X77 + 2242 X78 - 10.8 X150 - 10.5 X180 - 12.5 X207 - 9.5 X234 < 0

COWME14) 2026.04 X1 + 2053.97 X2 + 2103.07 X3 + 2148.27 X4 + 2194.89 X5 + 2247.07 X6 + 2289.57 X7 + 2342.07 X8 + 2387.06 X9 + 2425.05 X10 + 2424.17 X11 + 2349.71 X12 + 2235.80 X13 + 2007.86 X14 + 1626.16 X21 + 2031.90 X22 + 1996.42 X23 + 1965.05 X24 + 1963.04 X25 + 1980.53 X26 + 2042.77 X27 + 2071.21 X28 + 2121.28 X29 + 2167.14 X30 + 2214.61 X31 + 2267.44 X32 + 2310.68 X33 + 2363.74 X34 + 2409.37 X35 + 2447.87 X36 + 2446.99 X37 + 2277.20 X38 + 2167.29 X39 + 2026.51 X40 + 0.00 X41 + 0.00 X42 + 0.00 X43 + 0.00 X44 + 1142.49 X45 + 2043.28 X46 + 1992.10 X47 + 1986.80 X48 + 2010.46 X49 + 1979.77 X50 + 1978.38 X51 + 1996.37 X52 + 2242 X53 + 2277 X54 + 2334 X55 + 2387 X56 + 2442 X57 + 2502 X58 + 2552 X59 + 2612 X60 + 2664 X61 + 2709 X62 + 2709 X63 + 2629 X64 + 2525 X65 + 2245 X66 + 0.00 X67 + 0.00 X68 + 0.00 X69 + 0.00 X70 + 1235 X71 + 2216 X72 + 2166 X73 + 2164 X74 + 2192 X75 + 2164 X76 + 2167 X77 + 2189 X78 - 10.8 X151 - 10.5 X181 - 12.5 X208 - 9.5 X235 < 0

COWME15) 1980.53 X1 + 2026.04 X2 + 2053.97 X3 + 2103.07 X4 + 2148.27 X5 + 2194.89 X6 + 2247.07 X7 + 2289.57 X8 + 2342.07 X9 + 2387.06 X10 + 2425.05 X11 + 2424.17 X12 + 2349.71 X13 + 2235.80 X14 + 2007.86 X15 + 1626.16 X22 + 2031.90 X23 + 1996.42 X24 + 1965.05 X25 + 1963.04 X26 + 1996.37 X27 + 2042.77 X28 + 2071.21 X29 + 2121.28 X30 + 2167.14 X31 + 2214.61 X32 + 2267.44 X33 + 2310.68 X34 + 2363.74 X35 + 2409.37 X36 + 2447.87 X37 + 2446.99 X38 + 2277.20 X39 + 2167.29 X40 + 2026.51 X41 + 0.00 X42 + 0.00 X43 + 0.00 X44 + 0.00 X45 + 1142.49 X46 + 2043.28 X47 + 1992.10 X48 + 1986.80 X49 + 2010.46 X50 + 1979.77 X51 + 1978.38 X52 + 2189 X53 + 2242 X54 + 2277 X55 + 2334 X56 + 2387 X57 + 2442 X58 + 2502 X59 + 2552 X60 + 2612 X61 + 2664 X62 + 2709 X63 + 2709 X64 + 2629 X65 + 2525 X66 + 2245 X67 + 0.00 X68 + 0.00 X69 + 0.00 X70 + 0.00 X71 + 1235 X72 + 2216 X73 + 2166 X74 + 2164 X75 + 2192 X76 + 2164 X77 + 2167 X78 - 10.6 X152 - 10.5 X182 - 12.5 X209 - 9.5 X236 < 0

COWME16) 1963.04 X1 + 1980.53 X2 + 2026.04 X3 + 2053.97 X4 + 2103.07 X5 + 2148.27 X6 + 2194.89 X7 + 2247.07 X8 + 2289.57 X9 + 2342.07 X10 + 2387.06 X11 + 2425.05 X12 + 2424.17 X13 + 2349.71 X14 + 2235.80 X15 + 2007.86 X16 + 1626.16 X23 + 2031.90 X24 + 1996.42 X25 + 1965.05 X26 + 1978.38 X27 + 1996.37 X28 + 2042.77 X29 + 2071.21 X30 + 2121.28 X31 + 2167.14 X32 + 2214.61 X33 + 2267.44 X34 + 2310.68 X35 + 2363.74 X36 + 2409.37 X37 + 2447.87 X38 + 2446.99 X39 + 2277.20 X40 + 2167.29 X41 + 2026.51 X42 + 0.00 X43 + 0.00 X44 + 0.00 X45 + 0.00 X46 + 1142.49 X47 + 2043.28 X48 + 1992.10

X49 + 1986.80 X50 + 2010.46 X51 + 1979.77 X52 + 2167 X53 + 2189 X54 + 2242 X55 + 2277 X56 + 2334 X57 + 2387 X58 + 2442 X59 + 2502 X60 + 2552 X61 + 2612 X62 + 2664 X63 + 2709 X64 + 2709 X65 + 2629 X66 + 2525 X67 + 2245 X68 + 0.00 X69 + 0.00 X70 + 0.00 X71 + 0.00 X72 + 1235 X73 + 2216 X74 + 2166 X75 + 2164 X76 + 2192 X77 + 2164 X78 - 10.6 X153 - 10.5 X183 - 12.5 X210 - 9.5 X237 < 0

COWME17) 1965.05 X1 + 1963.04 X2 + 1980.53 X3 + 2026.04 X4 + 2053.97 X5 + 2103.07 X6 + 2148.27 X7 + 2194.89 X8 + 2247.07 X9 + 2289.57 X10 + 2342.07 X11 + 2387.06 X12 + 2425.05 X13 + 2424.17 X14 + 2349.71 X15 + 2235.80 X16 + 2007.86 X17 + 1626.16 X24 + 2031.90 X25 + 1996.42 X26 + 1979.77 X27 + 1978.38 X28 + 1996.37 X29 + 2042.77 X30 + 2071.21 X31 + 2121.28 X32 + 2167.14 X33 + 2214.61 X34 + 2267.44 X35 + 2310.68 X36 + 2363.74 X37 + 2409.37 X38 + 2447.87 X39 + 2446.99 X40 + 2277.20 X41 + 2167.29 X42 + 2026.51 X43 + 0.00 X44 + 0.00 X45 + 0.00 X46 + 0.00 X47 + 1142.49 X48 + 2043.28 X49 + 1992.10 X50 + 1986.80 X51 + 2010.46 X52 + 2164 X53 + 2167 X54 + 2189 X55 + 2242 X56 + 2277 X57 + 2334 X58 + 2387 X59 + 2442 X60 + 2502 X61 + 2552 X62 + 2612 X63 + 2664 X64 + 2709 X65 + 2709 X66 + 2629 X67 + 2525 X68 + 2245 X69 + 0.00 X70 + 0.00 X71 + 0.00 X72 + 0.00 X73 + 1235 X74 + 2216 X75 + 2166 X76 + 2164 X77 + 2192 X78 - 10.5 X154 - 10.5 X184 - 12.5 X211 - 9.5 X238 < 0

COWME18) 1996.42 X1 + 1965.05 X2 + 1963.04 X3 + 1980.53 X4 + 2026.04 X5 + 2053.97 X6 + 2103.07 X7 + 2148.27 X8 + 2194.89 X9 + 2247.07 X10 + 2289.57 X11 + 2342.07 X12 + 2387.06 X13 + 2425.05 X14 + 2424.17 X15 + 2349.71 X16 + 2235.80 X17 + 2007.86 X18 + 1626.16 X25 + 2031.90 X26 + 2010.46 X27 + 1979.77 X28 + 1978.38 X29 + 1996.37 X30 + 2042.77 X31 + 2071.21 X32 + 2121.28 X33 + 2167.14 X34 + 2214.61 X35 + 2267.44 X36 + 2310.68 X37 + 2363.74 X38 + 2409.37 X39 + 2447.87 X40 + 2446.99 X41 + 2277.20 X42 + 2167.29 X43 + 2026.51 X44 + 0.00 X45 + 0.00 X46 + 0.00 X47 + 0.00 X48 + 1142.49 X49 + 2043.28 X50 + 1992.10 X51 + 1986.80 X52 + 2192 X53 + 2164 X54 + 2167 X55 + 2189 X56 + 2242 X57 + 2277 X58 + 2334 X59 + 2387 X60 + 2442 X61 + 2502 X62 + 2552 X63 + 2612 X64 + 2664 X65 + 2709 X66 + 2709 X67 + 2629 X68 + 2525 X69 + 2245 X70 + 0.00 X71 + 0.00 X72 + 0.00 X73 + 0.00 X74 + 1235 X75 + 2216 X76 + 2166 X77 + 2164 X78 - 10.5 X155 - 10.5 X185 - 12.5 X212 - 9.5 X239 < 0

COWME19) 2031.90 X1 + 1996.42 X2 + 1965.05 X3 + 1963.04 X4 + 1980.53 X5 + 2026.04 X6 + 2053.97 X7 + 2103.07 X8 + 2148.27 X9 + 2194.89 X10 + 2247.07 X11 + 2289.57 X12 + 2342.07 X13 + 2387.06 X14 + 2425.05 X15 + 2424.17 X16 + 2349.71 X17 + 2235.80 X18 + 2007.86 X19 + 1626.16 X26 + 1986.80 X27 + 2010.46 X28 + 1979.77 X29 + 1978.38 X30 + 1996.37 X31 + 2042.77 X32 + 2071.21 X33 + 2121.28 X34 + 2167.14 X35 + 2214.61 X36 + 2267.44 X37 + 2310.68 X38 + 2363.74 X39 + 2409.37 X40 + 2447.87 X41 + 2446.99 X42 + 2277.20 X43 + 2167.29 X44 + 2026.51 X45 + 0.00 X46 + 0.00 X47 + 0.00 X48 + 0.00 X49 + 1142.49 X50 + 2043.28 X51 + 1992.10 X52 + 2164 X53 + 2192 X54 + 2164 X55 + 2167 X56 + 2189 X57 + 2242 X58 + 2277 X59 + 2334 X60 + 2387 X61 + 2442 X62 + 2502 X63 + 2552 X64 + 2612 X65 + 2664 X66 + 2709 X67 + 2709 X68 + 2629 X69 + 2525 X70 + 2245 X71 + 0.00 X72 + 0.00 X73 + 0.00 X74 + 0.00 X75 + 1235 X76 + 2216 X77 + 2166 X78 - 10.6 X156 - 10.5 X186 - 12.5 X213 - 9.5 X240 < 0

COWME20) 757.98 X1 + 2031.90 X2 + 1996.42 X3 + 1965.05 X4 + 1963.04 X5 + 1980.53 X6 + 2026.04 X7 + 2053.97 X8 + 2103.07 X9 + 2148.27 X10 + 2194.89 X11 + 2247.07 X12 + 2289.57 X13 + 2342.07 X14 + 2387.06 X15 + 2425.05 X16 + 2424.17 X17 + 2349.71 X18 + 2235.80 X19 + 2007.86 X20 + 1992.10 X27 + 1986.80 X28 + 2010.46 X29 + 1979.77 X30 + 1978.38 X31 + 1996.37 X32 + 2042.77 X33 + 2071.21 X34 + 2121.28 X35 + 2167.14 X36 + 2214.61 X37 + 2267.44 X38 + 2310.68 X39 + 2363.74 X40 + 2409.37 X41 + 2447.87 X42 + 2446.99 X43 + 2277.20 X44 + 2167.29 X45 + 2026.51 X46 + 0.00 X47 + 0.00 X48 + 0.00 X49 + 0.00 X50 + 1142.49 X51 + 2043.28 X52 + 2166 X53 + 2164 X54 + 2192 X55 + 2164 X56 + 2167 X57 + 2189 X58 + 2242 X59 + 2277 X60 + 2334 X61 + 2387 X62 + 2442 X63 + 2502 X64 + 2552 X65 + 2612 X66 + 2664 X67 + 2709 X68 + 2709 X69 + 2629 X70 + 2525 X71 + 2245 X72 + 0.00 X73 + 0.00 X74 +

0.00 X75 + 0.00 X76 + 1235 X77 + 2216 X78 - 10.6 X157 - 10.5 X187 - 12.5 X214 - 9.5 X241 < 0

COWME21) 1626.16 X2 + 2031.90 X3 + 1996.42 X4 + 1965.05 X5 + 1963.04 X6 + 1980.53 X7 + 2026.04 X8 + 2053.97 X9 + 2103.07 X10 + 2148.27 X11 + 2194.89 X12 + 2247.07 X13 + 2289.57 X14 + 2342.07 X15 + 2387.06 X16 + 2425.05 X17 + 2424.17 X18 + 2349.71 X19 + 2235.80 X20 + 2007.86 X21 + 2043.28 X27 + 1992.10 X28 + 1986.80 X29 + 2010.46 X30 + 1979.77 X31 + 1978.38 X32 + 1996.37 X33 + 2042.77 X34 + 2071.21 X35 + 2121.28 X36 + 2167.14 X37 + 2214.61 X38 + 2267.44 X39 + 2310.68 X40 + 2363.74 X41 + 2409.37 X42 + 2447.87 X43 + 2446.99 X44 + 2277.20 X45 + 2167.29 X46 + 2026.51 X47 + 1142.49 X52 + 2216 X53 + 2166 X54 + 2164 X55 + 2192 X56 + 2164 X57 + 2167 X58 + 2189 X59 + 2242 X60 + 2277 X61 + 2334 X62 + 2387 X63 + 2442 X64 + 2502 X65 + 2552 X66 + 2612 X67 + 2664 X68 + 2709 X69 + 2709 X70 + 2629 X71 + 2525 X72 + 2245 X73 + 0.00 X74 + 0.00 X75 + 0.00 X76 + 0.00 X77 + 1235 X78 - 10.9 X158 - 10.5 X188 - 12.5 X215 - 9.5 X242 < 0

COWME22) 1626.16 X3 + 2031.90 X4 + 1996.42 X5 + 1965.05 X6 + 1963.04 X7 + 1980.53 X8+ 2026.04 X9 + 2053.97 X10 + 2103.07 X11 + 2148.27 X12 + 2194.89 X13 + 2247.07 X14 + 2289.57 X15 + 2342.07 X16 + 2387.06 X17 + 2425.05 X18 + 2424.17 X19 + 2349.71 X20 + 2235.80 X21 + 2007.86 X22 + 1142.49 X27 + 2043.28 X28 + 1992.10 X29 + 1986.80 X30 + 2010.46 X31 + 1979.77 X32 + 1978.38 X33 + 1996.37 X34 + 2042.77 X35 + 2071.21 X36 + 2121.28 X37 + 2167.14 X38 + 2214.61 X39 + 2267.44 X40 + 2310.68 X41 + 2363.74 X42 + 2409.37 X43 + 2447.87 X44 + 2446.99 X45 + 2277.20 X46 + 2167.29 X47 + 2026.51 X48 + 1235 X53 + 2216 X54 + 2166 X55 + 2164 X56 + 2192 X57 + 2164 X58 + 2167 X59 + 2189 X60 + 2242 X61 + 2277 X62 + 2334 X63 + 2387 X64 + 2442 X65 + 2502 X66 + 2552 X67 + 2612 X68 + 2664 X69 + 2709 X70 + 2709 X71 + 2629 X72 + 2525 X73 + 2245 X74 + 0.00 X75 + 0.00 X76 + 0.00 X77 + 0.00 X78 - 10.9 X159 - 10.5 X189 - 12.5 X216 - 9.5 X243< 0

COWME23) 1626.16 X4 + 2031.90 X5 + 1996.42 X6 + 1965.05 X7 + 1963.04 X8 + 1980.53 X9 + 2026.04 X10 + 2053.97 X11 + 2103.07 X12 + 2148.27 X13 + 2194.89 X14 + 2247.07 X15 + 2289.57 X16 + 2342.07 X17 + 2387.06 X18 + 2425.05 X19 + 2424.17 X20 + 2349.71 X21 + 2235.80 X22 + 2007.86 X23 + 1142.49 X28 + 2043.29 X29 + 1992.10 X30 + 1986.80 X31 + 2010.46 X32 + 1979.77 X33 + 1978.38 X34 + 1996.37 X35 + 2042.77 X36 + 2071.21 X37 + 2121.28 X38 + 2167.14 X39 + 2214.61 X40 + 2267.44 X41 + 2310.68 X42 + 2363.74 X43 + 2409.37 X44 + 2447.87 X45 + 2446.99 X46 + 2277.20 X47 + 2167.29 X48 + 2026.51 X49 + 1235 X54 + 2216 X55 + 2166 X56 + 2164 X57 + 2192 X58 + 2164 X59 + 2167 X60 + 2189 X61 + 2242 X62 + 2277 X63 + 2334 X64 + 2387 X65 + 2442 X66 + 2502 X67 + 2552 X68 + 2612 X69 + 2664 X70 + 2709 X71 + 2709 X72 + 2629 X73 + 2525 X74 + 2245 X75 - 11.2 X160 - 10.5 X190 - 12.5 X217 - 9.5 X244 < 0

COWME24) 1626.16 X5 + 2031.90 X6 + 1996.42 X7 + 1965.05 X8 + 1963.04 X9 + 1980.53 X10 + 2026.04 X11 + 2053.97 X12 + 2103.07 X13 + 2148.27 X14 + 2194.89 X15 + 2247.07 X16 + 2289.57 X17 + 2342.07 X18 + 2387.06 X19 + 2425.05 X20 + 2424.17 X21 + 2349.71 X22 + 2235.80 X23 + 2007.86 X24 + 1142.49 X29 + 2043.28 X30 + 1992.10 X31 + 1986.80 X32 + 2010.46 X33 + 1979.77 X34 + 1978.38 X35 + 1996.37 X36 + 2042.77 X37 + 2071.21 X38 + 2121.28 X39 + 2167.14 X40 + 2214.61 X41 + 2267.44 X42 + 2310.68 X43 + 2363.74 X44 + 2409.37 X45 + 2447.87 X46 + 2446.99 X47 + 2277.20 X48 + 2167.29 X49 + 2026.51 X50 + 1235 X55 + 2216 X56 + 2166 X57 + 2164 X58 + 2192 X59 + 2164 X60 + 2167 X61 + 2189 X62 + 2242 X63 + 2277 X64 + 2334 X65 + 2387 X66 + 2442 X67 + 2502 X68 + 2552 X69 + 2612 X70 + 2664 X71 + 2709 X72 + 2709 X73 + 2629 X74 + 2525 X75 + 2245 X76 - 11.2 X161 - 10.5 X191 - 12.5 X218 - 9.5 X245 < 0

COWME25) 1626.16 X6 + 2031.90 X7 + 1996.42 X8 + 1965.05 X9 + 1963.04 X10 + 1980.53 X11 + 2026.04 X12 + 2053.97 X13 + 2103.07 X14 + 2148.27 X15 + 2194.89 X16 + 2247.07 X17 + 2289.57 X18 + 2342.07 X19 + 2387.06 X20 + 2425.05 X21 + 2424.17 X22 + 2349.71 X23 + 2235.80 X24 + 2007.86 X25 + 1142.49 X30 + 2043.28 X31 + 1992.10 X32 + 1986.80 X33 + 2010.46 X34 +

1979.77 X35 + 1978.38 X36 + 1996.37 X37 + 2042.77 X38 + 2071.21 X39 + 2121.28 X40 + 2167.14 X41 + 2214.61 X42 + 2267.44 X43 + 2310.68 X44 + 2363.74 X45 + 2409.37 X46 + 2447.87 X47 + 2446.99 X48 + 2277.20 X49 + 2167.29 X50 + 2026.51 X51 + 1235 X56 + 2216 X57 + 2166 X58 + 2164 X59 + 2192 X60 + 2164 X61 + 2167 X62 + 2189 X63 + 2242 X64 + 2277 X65 + 2334 X66 + 2387 X67 + 2442 X68 + 2502 X69 + 2552 X70 + 2612 X71 + 2664 X72 + 2709 X73 + 2709 X74 + 2629 X75 + 2525 X76 + 2245 X77 - 11.4 X162 - 10.5 X192 - 12.5 X219 - 9.5 X246 < 0

COWME26) 1626.16 X7 + 2031.90 X8 + 1996.42 X9 + 1965.05 X10 + 1963.04 X11 + 1980.53 X12 + 2026.04 X13 + 2053.97 X14 + 2103.07 X15 + 2148.27 X16 + 2194.89 X17 + 2247.07 X18 + 2289.57 X19 + 2342.07 X20 + 2387.06 X21 + 2425.05 X22 + 2424.17 X23 + 2349.71 X24 + 2235.80 X25 + 2007.86 X26 + 0.00 X27 + 1142.49 X31 + 2043.28 X32 + 1992.10 X33 + 1986.80 X34 + 2010.46 X35 + 1979.77 X36 + 1978.38 X37 + 1996.37 X38 + 2042.77 X39 + 2071.21 X40 + 2121.28 X41 + 2167.14 X42 + 2214.61 X43 + 2267.44 X44 + 2310.68 X45 + 2363.74 X46 + 2409.37 X47 + 2447.87 X48 + 2446.99 X49 + 2277.20 X50 + 2167.29 X51 + 2026.51 X52 + 1235 X57 + 2216 X58 + 2166 X59 + 2164 X60 + 2192 X61 + 2164 X62 + 2167 X63 + 2189 X64 + 2242 X65 + 2277 X66 + 2334 X67 + 2387 X68 + 2442 X69 + 2502 X70 + 2552 X71 + 2612 X72 + 2664 X73 + 2709 X74 + 2709 X75 + 2629 X76 + 2525 X77 + 2245 X78 - 11.4 X163 - 10.5 X193 - 12.5 X220 - 9.5 X247 < 0

COWCP01) 30.66 X1 + 21.46 X8 + 24.48 X9 + 24.87 X10 + 25.27 X11 + 25.79 X12 + 26.44 X13 + 27.06 X14 + 27.82 X15 + 28.53 X16 + 29.37 X17 + 30.15 X18 + 31.02 X19 + 31.73 X20 + 32.60 X21 + 33.26 X22 + 33.87 X23 + 34.19 X24 + 34.16 X25 + 33.70 X26 + 30.94 X27 + 11.96 X32 + 23.77 X33 + 24.13 X34 + 24.66 X35 + 25.10 X36 + 25.52 X37 + 26.05 X38 + 26.68 X39 + 27.28 X40 + 27.59 X41 + 28.50 X42 + 29.48 X43 + 30.34 X44 + 31.32 X45 + 32.05 X46 + 32.92 X47 + 33.58 X48 + 34.21 X49 + 34.52 X50 + 34.50 X51 + 34.03 X52 + 32.51 X53 + 12.67 X58 + 24.94 X59 + 25.18 X60 + 25.74 X61 + 26.20 X62 + 26.69 X63 + 27.27 X64 + 27.95 X65 + 28.68 X66 + 29.48 X67 + 30.24 X68 + 31.19 X69 + 31.97 X70 + 32.95 X71 + 33.68 X72 + 34.61 X73 + 35.32 X74 + 35.94 X75 + 36.27 X76 + 36.25 X77 + 35.74 X78 - 0.26 X138 - 0.16 X168 - .1 X195 - .12 X222 < 0

COWCP02) 33.70 X1 + 30.66 X2 + 21.46 X9 + 24.48 X10 + 24.87 X11 + 25.27 X12 + 25.79 X13 + 26.44 X14 + 27.06 X15 + 27.82 X16 + 28.53 X17 + 29.37 X18 + 30.15 X19 + 31.02 X20 + 31.73 X21 + 32.60 X22 + 33.26 X23 + 33.87 X24 + 34.19 X25 + 34.16 X26 + 34.03 X27 + 30.94 X28 + 11.96 X33 + 23.77 X34 + 24.13 X35 + 24.66 X36 + 25.10 X37 + 25.52 X38 + 26.05 X39 + 26.68X40 + 27.28 X41 + 27.59 X42 + 28.50 X43 + 29.48 X44 + 30.34 X45 + 31.32 X46 + 32.05 X47 + 32.92 X48 + 33.58 X49 + 34.21 X50 + 34.52 X51 + 34.50 X52 +35.74 X53 + 32.51 X54 + 12.67 X59 + 24.94 X60 + 25.18 X61 + 25.74 X62 + 26.20 X63 + 26.69 X64 + 27.27 X65 + 27.95 X66 +28.68 X67 + 29.48 X68 + 30.24 X69 +31.19 X70 + 31.97 X71 + 32.95 X72 + 33.68 X73 + 34.61 X74 + 35.32 X75 + 35.94 X76 + 36.27 X77 + 36.25 X78 - 0.26 X139 - 0.16 X169 - .1 X196 - .12 X223 < 0

COWCP03) 34.16 X1 + 33.70 X2 + 30.66 X3 + 21.46 X10 + 24.48 X11 + 24.87 X12 + 25.27 X13 + 25.79 X14 + 26.44 X15 + 27.06 X16 + 27.82 X17 + 28.53 X18 + 29.37 X19 + 30.15 X20 + 31.02 X21 + 31.73 X22 + 32.60 X23 + 33.26 X24 + 33.87 X25 + 34.19 X26 + 34.50 X27 + 34.03 X28 + 30.94 X29 + 11.96 X34 +23.77 X35 + 4.13 X36 + 24.66 X37 + 25.10 X38 + 25.52 X39 + 26.05 X40 +26.68 X41 + 27.28 X42 + 27.59 X43 + 28.50 X44 + 29.48 X45 + 30.34 X46 + 31.32 X47 + 32.05 X48 + 32.92 X49 + 33.58 X50 + 34.21 X51 + 34.52 X52 + 36.25 X53 + 35.74 X54 + 32.51 X55 + 12.67 X60 + 24.94 X61 + 25.18 X62 + 25.74 X63 + 26.20 X64 + 26.69 X65 + 27.27 X66 + 27.95 X67 + 28.68 X68 + 29.48 X69 + 30.24 X70 + 31.19 X71 + 31.97 X72 + 32.95 X73 + 33.68 X74 + 34.61 X75 + 35.32 X76 + 35.94 X77 + 36.27 X78 - 0.27 X140 - 0.16 X170 - .1 X197 - .12 X224 < 0

COWCP04) 34.19 X1 + 34.16 X2 + 33.70 X3 + 30.66 X4 + 21.46 X11 + 24.48 X12 + 24.87 X13 + 25.27 X14 + 25.79 X15 + 26.44 X16 + 27.06 X17 + 27.82 X18 + 28.53 X19 + 29.37 X20 + 30.15 X21 + 31.02 X22 + 31.73 X23 + 32.60 X24 +

33.26 X25 + 33.87 X26 + 34.52 X27 + 34.50 X28 + 34.03 X29 + 30.94 X30 + 11.96 X35 + 23.77 X36 + 24.13 X37 + 24.66 X38 + 25.10 X39 + 25.52 X40 +26.05 X41 + 26.68 X42 + 27.28 X43 + 27.59 X44 + 28.50 X45 + 29.48 X46 + 30.34 X47 + 31.32 X48 + 32.05 X49 + 32.92 X50 + 33.58 X51 + 34.21 X52 + 36.27 X53 + 36.25 X54 + 35.74 X55 + 32.51 X56 + 12.67 X61 + 24.94 X62 + 25.18 X63 + 25.74 X64 + 26.20 X65 + 26.69 X66 + 27.27 X67 + 27.95 X68 + 28.68 X69 +29.48 X70 + 30.24 X71 + 31.19 X72 + 31.97 X73 + 32.95 X74 + 33.68 X75 + 34.61 X76 + 35.32 X77 + 35.94 X78 - 0.26 X141 - 0.16 X171 - .1 X198 - .12 X225 < 0

COWCP05) 33.87 X1 + 34.19 X2 + 34.16 X3 + 33.70 X4 + 30.66 X5 + 21.46 X12 + 24.48 X13 + 24.87 X14 + 25.27 X15 + 25.79 X16 + 26.44 X17 + 27.06 X18 + 27.82 X19 + 28.53 X20 + 29.37 X21 + 30.15 X22 + 31.02 X23 + 31.73 X24 + 32.60 X25 + 33.26 X26 + 34.21 X27 + 34.52 X28 + 34.50 X29 + 34.03 X30 + 30.94 X31 + 11.96 X36 + 23.77 X37 + 24.13 X38 + 24.66 X39 + 25.10 X40 +25.52 X41 + 26.05 X42 + 26.68 X43 + 27.28 X44 + 27.59 X45 + 28.50 X46 + 29.48 X47 + 30.34 X48 + 31.32 X49 + 32.05 X50 + 32.92 X51 + 33.58 X52 + 35.94 X53 + 36.27 X54 + 36.25 X55 + 35.74 X56 + 32.51 X57 + 12.67 X62 + 24.94 X63 + 25.18 X64 + 25.74 X65 + 26.20 X66 + 26.69 X67 + 27.27 X68 + 27.95 X69 + 28.68 X70 + 29.48 X71 + 30.24 X72 + 31.19 X73 + 31.97 X74 + 32.95 X75 + 33.68 X76 + 34.61 X77 + 35.32 X78 - 0.26 X142 - 0.16 X172 - .1 X199 - .12 X226 < 0

COWCP06) 33.26 X1 + 33.87 X2 + 34.19 X3 + 34.16 X4 + 33.70 X5 + 30.66 X6 + 21.46 X13 + 24.48 X14 + 24.87 X15 + 25.27 X16 + 25.79 X17 + 26.44 X18 + 27.06 X19 + 27.82 X20 + 28.53 X21 + 29.37 X22 + 30.15 X23 + 31.02 X24 + 31.73 X25 + 32.60 X26 + 33.58 X27 + 34.21 X28 + 34.52 X29 + 34.50 X30 + 34.03 X31 + 30.94 X32 + 11.96 X37 + 23.77 X38 + 24.13 X39 + 24.66 X40 +25.10 X41 + 25.52 X42 + 26.05 X43 + 26.68 X44 + 27.28 X45 + 27.59 X46 + 28.50 X47 + 29.48 X48 + 30.34 X49 + 31.32 X50 + 32.05 X51 + 32.92 X52 + 35.32 X53 + 35.94 X54 + 36.27 X55 + 36.25 X56 + 35.74 X57 + 32.51 X58 + 12.67 X63 + 24.94 X64 + 25.18 X65 + 25.74 X66 + 26.20 X67 + 26.69 X68 + 27.27 X69 +27.95 X70 + 28.68 X71 + 29.48 X72 + 30.24 X73 + 31.19 X74 + 31.97 X75 + 32.95 X76 + 33.68 X77 + 34.61 X78 - 0.25 X143 - 0.16 X173 - .1 X200 - .12 X227 < 0

COWCP07) 32.60 X1 + 33.26 X2 + 33.87 X3 + 34.19 X4 + 34.16 X5 + 33.70 X6 + 30.66 X7 + 21.46 X14 + 24.48 X15 + 24.87 X16 + 25.27 X17 + 25.79 X18 + 26.44 X19 + 27.06 X20 + 27.82 X21 + 28.53 X22 + 29.37 X23 + 30.15 X24 + 31.02 X25 + 31.73 X26 + 32.92 X27 + 33.58 X28 + 34.21 X29 + 34.52 X30 + 34.50 X31 + 34.03 X32 + 30.94 X33 + 11.96 X38 + 23.77 X39 + 24.13 X40 +24.66 X41 + 25.10 X42 + 25.52 X43 + 26.05 X44 + 26.68 X45 + 27.28 X46 + 27.59 X47 + 28.50 X48 + 29.48 X49 + 30.34 X50 + 31.32 X51 + 32.05 X52 + 34.61 X53 + 35.32 X54 + 35.94 X55 + 36.27 X56 + 36.25 X57 + 35.74 X58 + 32.51 X59 + 12.67 X64 + 24.94 X65 + 25.18 X66 + 25.74 X67 + 26.20 X68 + 26.69 X69 + 27.27 X70 + 27.95 X71 + 28.68 X72 + 29.48 X73 + 30.24 X74 + 31.19 X75 + 31.97 X76 + 32.95 X77 + 33.68 X78 - 0.24 X144 - 0.16 X174 - .1 X201 - .12 X228 < 0

COWCP08) 31.73 X1 + 32.60 X2 + 33.26 X3 + 33.87 X4 + 34.19 X5 + 34.16 X6 + 33.70 X7 + 30.66 X8 + 21.46 X15 + 24.48 X16 + 24.87 X17 + 25.27 X18 + 25.79 X19 + 26.44 X20 + 27.06 X21 + 27.82 X22 + 28.53 X23 + 29.37 X24 + 30.15 X25 + 31.02 X26 + 32.05 X27 + 32.92 X28 + 33.58 X29 + 34.21 X30 + 34.52 X31 + 34.50 X32 + 34.03 X33 + 30.94 X34 + 11.96 X39 + 23.77 X40 + 24.13 X41 +24.66 X42 + 25.10 X43 + 25.52 X44 + 26.05 X45 + 26.68 X46 + 27.28 X47 + 27.59 X48 + 28.50 X49 + 29.48 X50 + 30.34 X51 + 31.32 X52 + 33.68 X53 + 34.61 X54 + 35.32 X55 + 35.94 X56 + 36.27 X57 + 36.25 X58 + 35.74 X59 + 32.51 X60 + 12.67 X65 + 24.94 X66 + 25.18 X67 + 25.74 X68 + 26.20 X69 + 26.69 X70 + 27.27 X71 + 27.95 X72 + 28.68 X73 + 29.48 X74 + 30.24 X75 + 31.19 X76 + 31.97 X77 + 32.95 X78 - 0.24 X145 - 0.16 X175 - .1 X202 - .12 X229 < 0

COWCP09) 31.02 X1 + 31.73 X2 + 32.60 X3 + 33.26 X4 + 33.87 X5 + 34.19 X6 + 34.16 X7 + 33.70 X8 + 30.66 X9 + 21.46 X16 + 24.48 X17 + 24.87 X18 + 25.27 X19 + 25.79 X20 + 26.44 X21 + 27.06 X22 + 27.82 X23 + 28.53 X24 + 29.37 X25 + 30.15 X26 + 31.32 X27 + 32.05 X28 + 32.92 X29 + 33.58 X30 + 34.21 X31 + 34.52 X32 + 34.50 X33 + 34.03 X34 + 30.94 X35 + 11.96 X40 + 23.77 X41 +24.13 X42 + 24.66 X43 + 25.10 X44 + 25.52 X45 + 26.05 X46 + 26.68 X47 + 27.28 X48

+ 27.59 X49 + 28.50 X50 + 29.48 X51 + 30.34 X52 + 32.95 X53 + 33.68 X54 + 34.61 X55 + 35.32 X56 + 35.94 X57 + 36.27 X58 + 36.25 X59 + 35.74 X60 + 32.51 X61 + 12.67 X66 + 24.94 X67 + 25.18 X68 + 25.74 X69 + 26.20 X70 + 26.69 X71 + 27.27 X72 + 27.95 X73 + 28.68 X74 + 29.48 X75 + 30.24 X76+ 31.19 X77 + 31.97 X78 - 0.23 X146 - 0.16 X176 - .1 X203 - .12 X230 < 0

COWCP10) 30.15 X1 + 31.02 X2 + 31.73 X3 + 32.60 X4 + 33.26 X5 + 33.87 X6 + 34.19 X7 + 34.16 X8 + 33.70 X9 + 30.66 X10 + 21.46 X17 + 24.48 X18 + 24.87 X19 + 25.27 X20 + 25.79 X21 + 26.44 X22 + 27.06 X23 + 27.82 X24 + 28.53 X25 + 29.37 X26 + 30.34 X27 + 31.32 X28 + 32.05 X29 + 32.92 X30 + 33.58 X31 + 34.21 X32 + 34.52 X33 + 34.50 X34 + 34.03 X35 + 30.94 X36 + 11.96 X41 +23.77 X42 + 24.13 X43 + 24.66 X44 + 25.10 X45 + 25.52 X46 + 26.05 X47 + 26.68 X48 + 27.28 X49 + 27.59 X50 + 28.50 X51 + 29.48 X52 + 31.97 X53 + 32.95 X54 + 33.68 X55 + 34.61 X56 + 35.32 X57 + 35.94 X58 + 36.27 X59 + 36.25 X60 + 35.74 X61 + 32.51 X62 + 12.67 X67 + 24.94 X68 + 25.18 X69 + 25.74 X70 +26.20 X71 + 26.69 X72 + 27.27 X73 + 27.95 X74 + 28.68 X75 + 29.48 X76 + 30.24 X77 + 31.19 X78 - 0.23 X147 - 0.16 X177 - .1 X204 - .12 X231 < 0

COWCP11) 29.37 X1 + 30.15 X2 + 31.02 X3 + 31.73 X4 + 32.60 X5 + 33.26 X6 + 33.87 X7 + 34.19 X8 + 34.16 X9 + 33.70 X10 + 30.66 X11 + 21.46 X18 + 24.48 X19 + 24.87 X20 + 25.27 X21 + 25.79 X22 + 26.44 X23 + 27.06 X24 + 27.82 X25 + 28.53 X26 + 29.48 X27 + 30.34 X28 + 31.32 X29 + 32.05 X30 + 32.92 X31 + 33.58 X32 + 34.21 X33 + 34.52 X34 + 34.50 X35 + 34.03 X36 + 30.94 X37 + 1.96 X42 + 23.77 X43 + 24.13 X44 + 24.66 X45 + 25.10 X46 + 25.52 X47 + 26.05 X48 + 26.68 X49 + 27.28 X50 + 27.59 X51 + 28.50 X52 + 31.19 X53 + 31.97 X54 + 32.95 X55 + 33.68 X56 + 34.61 X57 + 35.32 X58 + 35.94 X59 + 36.27 X60 + 36.25 X61 + 35.74 X62 + 32.51 X63 + 12.67 X68 + 24.94 X69 + 25.18 X70 + 25.74 X71 + 26.20 X72 + 26.69 X73 + 27.27 X74 + 27.95 X75 + 28.68 X76 + 29.48 X77 + 30.24 X78 - 0.22 X148 - 0.16 X178 - .1 X205 - .12 X232 < 0

COWCP12) 28.53 X1 + 29.37 X2 + 30.15 X3 + 31.02 X4 + 31.73 X5 + 32.60 X6 + 33.26 X7 + 33.87 X8 + 34.19 X9 + 34.16 X10 + 33.70 X11 + 30.66 X12 + 21.46 X19 + 24.48 X20 + 24.87 X21 + 25.27 X22 + 25.79 X23 + 26.44 X24 + 27.06 X25 + 27.82 X26 + 28.50 X27 + 29.48 X28 + 30.34 X29 + 31.32 X30 + 32.05 X31 + 32.92 X32 + 33.58 X33 + 34.21 X34 + 34.52 X35 + 34.50 X36 + 34.03 X37 +30.94 X38 + 11.96 X43 + 23.77 X44 + 24.13 X45 + 24.66 X46 + 25.10 X47 + 25.52 X48 + 26.05 X49 + 26.68 X50 + 27.28 X51 + 27.59 X52 + 30.24 X53 + 31.19 X54 + 31.97 X55 + 32.95 X56 + 33.68 X57 + 34.61 X58 + 35.32 X59 + 35.94 X60 + 36.27 X61 + 36.25 X62 + 35.74 X63 +32.51 X64 + 12.67 X69 + 24.94X70 + 25.18 X71 + 25.74 X72 + 26.20 X73 + 26.69 X74 + 27.27 X75 + 27.95 X76 + 28.68 X77 + 29.48 X78 - 0.22 X149 - 0.16 X179 - .1 X206 - .12 X233 < 0

COWCP13) 27.82 X1 + 28.53 X2 + 29.37 X3 + 30.15 X4 + 31.02 X5 + 31.73 X6 + 32.60 X7 + 33.26 X8 + 33.87 X9 + 34.19 X10 + 34.16 X11 + 33.70 X12 + 30.66 X13 + 21.46 X20 + 24.48 X21 + 24.87 X22 + 25.27 X23 + 25.79 X24 + 26.44 X25 + 27.06 X26 + 27.59 X27 + 28.50 X28 + 29.48 X29 + 30.34 X30 + 31.32 X31 + 32.05 X32 + 32.92 X33 + 33.58 X34 + 34.21 X35 + 34.52 X36 + 34.50 X37 +34.03 X38 + 30.94 X39 + 11.96 X44 + 23.77 X45 + 24.13 X46 + 24.66 X47 + 25.10 X48 + 25.52 X49 + 26.05 X50 + 26.68 X51 + 27.28 X52 + 29.48 X53 + 30.24 X54 + 31.19 X55 + 31.97 X56 + 32.95 X57 + 33.68 X58 + 34.61 X59 + 35.32 X60 + 35.94 X61 + 36.27 X62 + 36.25 X63 + 35.74 X64 + 32.51 X65 + 12.67 X70 + 24.94 X71 + 25.18 X72 + 25.74 X73 + 26.20 X74 + 26.69 X75 + 27.27 X76+ 27.95 X77 + 28.68 X78 - 0.21 X150 - 0.16 X180 - .1 X207 - .12 X234 < 0

COWCP14) 27.06 X1 + 27.82 X2 + 28.53 X3 + 29.37 X4 + 30.15 X5 + 31.02 X6 + 31.73 X7 + 32.60 X8 + 33.26 X9 + 33.87 X10 + 34.19 X11 + 34.16 X12 + 33.70 X13 + 30.66 X14 + 21.46 X21 + 24.48 X22 + 24.87 X23 + 25.27 X24 + 25.79 X25 + 26.44 X26 + 27.28 X27 + 27.59 X28 + 28.50 X29 + 29.48 X30 + 30.34 X31 + 31.32 X32 + 32.05 X33 + 32.92 X34 + 33.58 X35 + 34.21 X36 + 34.52 X37 +34.50 X38 + 34.03 X39 + 30.94 X40 + 11.96 X45 + 23.77 X46 + 24.13 X47 + 24.66 X48 + 25.10 X49 + 25.52 X50 + 26.05 X51 + 26.68 X52 + 28.68 X53 + 29.48 X54 + 30.24 X55 + 31.19 X56 + 31.97 X57 + 32.95 X58 + 33.68 X59 + 34.61 X60 + 35.32 X61 + 35.94 X62 + 36.27 X63 + 36.25 X64 + 35.74 X65 + 32.51 X66 +

12.67 X71 + 24.94 X72 + 25.18 X73 + 25.74 X74 + 26.20 X75 + 26.69 X76 +27.27 X77 + 27.95 X78 - 0.15 X151 - 0.16 X181 - .1 X208 - .12 X235 < 0

COWCP15) 26.44 X1 + 27.06 X2 + 27.82 X3 + 28.53 X4 + 29.37 X5 + 30.15 X6 + 31.02 X7 + 31.73 X8 + 32.60 X9 + 33.26 X10 + 33.87 X11 + 34.19 X12 + 34.16 X13 + 33.70 X14 + 30.66 X15 + 21.46 X22 + 24.48 X23 + 24.87 X24 + 25.27 X25 + 25.79 X26 + 26.68 X27 + 27.28 X28 + 27.59 X29 + 28.50 X30 + 29.48 X31 + 30.34 X32 + 31.32 X33 + 32.05 X34 + 32.92 X35 + 33.58 X36 + 34.21 X37 +34.52 X38 + 34.50 X39 + 34.03 X40 + 30.94 X41 + 11.96 X46 + 23.77 X47 + 24.13 X48 + 24.66 X49 + 25.10 X50 + 25.52 X51 + 26.05 X52 + 27.95 X53 + 28.68 X54 + 29.48 X55 + 30.24 X56 + 31.19 X57 + 31.97 X58 + 32.95 X59 + 33.68 X60 + 34.61 X61 + 35.32 X62 + 35.94 X63 + 36.27 X64 + 36.25 X65 + 35.74 X66 + 32.51 X67 + 12.67 X72 + 24.94 X73 + 25.18 X74 + 25.74 X75 + 26.20 X76 +26.69 X77 + 27.27 X78 - 0.15 X152 - 0.16 X182 - .1 X209 - .12 X236 < 0

COWCP16) 25.79 X1 + 26.44 X2 + 27.06 X3 + 27.82 X4 + 28.53 X5 + 29.37 X6 + 30.15 X7 + 31.02 X8 + 31.73 X9 + 32.60 X10 + 33.26 X11 + 33.87 X12 + 34.19 X13 + 34.16 X14 + 33.70 X15 + 30.66 X16 + 21.46 X23 + 24.48 X24 + 24.87 X25 + 25.27 X26 + 26.05 X27 + 26.68 X28 + 27.28 X29 + 27.59 X30 + 28.50 X31 + 29.48 X32 + 30.34 X33 + 31.32 X34 + 32.05 X35 + 32.92 X36 + 33.58 X37 +34.21 X38 + 34.52 X39 + 34.50 X40 + 34.03 X41 + 30.94 X42 + 11.96 X47 + 23.77 X48 + 24.13 X49 + 24.66 X50 + 25.10 X51 + 25.52 X52 + 27.27 X53 + 27.95 X54 + 28.68 X55 + 29.48 X56 + 30.24 X57 + 31.19 X58 + 31.97 X59 + 32.95 X60 + 33.68 X61 + 34.61 X62 + 35.32 X63 + 35.94 X64 + 36.27 X65 + 36.25 X66 + 35.74 X67 + 32.51 X68 + 12.67 X73 + 24.94 X74 + 25.18 X75 + 25.74 X76 +26.20 X77 + 26.69 X78 - 0.15 X153 - 0.16 X183 - .1 X210 - .12 X237 < 0

COWCP17) 25.27 X1 + 25.79 X2 + 26.44 X3 + 27.06 X4 + 27.82 X5 + 28.53 X6 + 29.37 X7 + 30.15 X8 + 31.02 X9 + 31.73 X10 + 32.60 X11 + 33.26 X12 + 33.87 X13 + 34.19 X14 + 34.16 X15 + 33.70 X16 + 30.66 X17 + 21.46 X24 + 24.48 X25 + 24.87 X26 + 25.52 X27 + 26.05 X28 + 26.68 X29 + 27.28 X30 + 27.59 X31 + 28.50 X32 + 29.48 X33 + 30.34 X34 + 31.32 X35 + 32.05 X36 + 32.92 X37 +33.58 X38 + 34.21 X39 + 34.52 X40 + 34.50 X41 + 34.03 X42 + 30.94 X43 + 11.96 X48 + 23.77 X49 + 24.13 X50 + 24.66 X51 + 25.10 X52 + 26.69 X53 + 27.27 X54 + 27.95 X55 + 28.68 X56 + 29.48 X57 + 30.24 X58 + 31.19 X59 + 31.97 X60 +32.95 X61 + 33.68 X62 + 34.61 X63 + 35.32 X64 + 35.94 X65 + 36.27 X66 + 36.25 X67 + 35.74 X68 + 32.51 X69 +12.67 X74 + 24.94 X75 + 25.18 X76 + 25.74 X77 + 26.20 X78 - 0.16 X154 - 0.16 X184 - .1 X211 - .12 X238 < 0

COWCP18) 24.87 X1 + 25.27 X2 + 25.79 X3 + 26.44 X4 + 27.06 X5 + 27.82 X6 + 28.53 X7 + 29.37 X8 + 30.15 X9 + 31.02 X10 + 31.73 X11 + 32.60 X12 + 33.26 X13 + 33.87 X14 + 34.19 X15 + 34.16 X16 + 33.70 X17 + 30.66 X18 + 21.46 X25 + 24.48 X26 + 25.10 X27 + 25.52 X28 + 26.05 X29 + 26.68 X30 + 27.28 X31 + 27.59 X32 + 28.50 X33 + 29.48 X34 + 30.34 X35 + 31.32 X36 + 32.05 X37 +32.92 X38 + 33.58 X39 + 34.21 X40 + 34.52 X41 + 34.50 X42 + 34.03 X43 + 30.94 X44 + 11.96 X49 + 23.77 X50 + 24.13 X51 + 24.66 X52 + 26.20 X53 + 26.69 X54 + 27.27 X55 + 27.95 X56 + 28.68 X57 + 29.48 X58 + 30.24 X59 + 31.19 X60 +31.97 X61 + 32.95 X62 + 33.68 X63 + 34.61 X64 + 35.32 X65 + 35.94 X66 + 36.27 X67 + 36.25 X68 + 35.74 X69 + 32.51 X70 + 12.67 X75 + 24.94 X76 + 25.18 X77 + 25.74 X78 - 0.16 X155 - 0.16 X185 - .1 X212 - .12 X239 < 0

COWCP19) 24.48 X1 + 24.87 X2 + 25.27 X3 + 25.79 X4 + 26.44 X5 + 27.06 X6 + 27.82 X7 + 28.53 X8 + 29.37 X9 + 30.15 X10 + 31.02 X11 + 31.73 X12 + 32.60 X13 + 33.26 X14 + 33.87 X15 + 34.19 X16 + 34.16 X17 + 33.70 X18 + 30.66 X19 + 21.46 X26 + 24.66 X27 + 25.10 X28 + 25.52 X29 + 26.05 X30 + 26.68 X31 + 27.28 X32 + 27.59 X33 + 28.50 X34 + 29.48 X35 + 30.34 X36 + 31.32 X37 +32.05 X38 + 32.92 X39 + 33.58 X40 + 34.21 X41 + 34.52 X42 + 34.50 X43 + 34.03 X44 + 30.94 X45 + 11.96 X50 + 23.77 X51 + 24.13 X52 + 25.74 X53 + 26.20 X54 + 26.69 X55 + 27.27 X56 + 27.95 X57 + 28.68 X58 + 29.48 X59 + 30.24 X60 +31.19 X61 + 31.97 X62 + 32.95 X63 + 33.68 X64 + 34.61 X65 + 35.32 X66 + 35.94 X67 + 36.27 X68 + 36.25 X69 + 35.74 X70 + 32.51 X71 + 12.67 X76 + 24.94 X77 + 25.18 X78 - 0.16 X156 - 0.16 X186 - .1 X213 - .12 X240 < 0

COWCP20) 8.70 X1 + 24.48 X2 + 24.87 X3 + 25.27 X4 + 25.79 X5 + 26.44 X6 + 27.06 X7 + 27.82 X8 + 28.53 X9 + 29.37 X10 + 30.15 X11 + 31.02 X12 + 31.73 X13 + 32.60 X14 + 33.26 X15 + 33.87 X16 + 34.19 X17 + 34.16 X18 + 33.70 X19 + 30.66 X20 + 24.13 X27 + 24.66 X28 + 25.10 X29 + 25.52 X30 + 26.05 X31 + 26.68 X32 + 27.28 X33 + 27.59 X34 + 28.50 X35 + 29.48 X36 + 30.34 X37 +31.32 X38 + 32.05 X39 + 32.92 X40 + 33.58 X41 + 34.21 X42 + 34.52 X43 + 34.50 X44 + 34.03 X45 + 30.94 X46 + 11.96 X51 + 23.77 X52 + 25.18 X53 + 25.74 X54 + 26.20 X55 + 26.69 X56 + 27.27 X57 + 27.95 X58 + 28.68 X59 + 29.48 X60 +30.24 X61 + 31.19 X62 + 31.97 X63 + 32.95 X64 + 33.68 X65 + 34.61 X66 + 35.32 X67 + 35.94 X68 + 36.27 X69 + 36.25 X70 + 35.74 X71 + 32.51 X72 + 12.67 X77 + 24.94 X78 - 0.17 X157 - 0.16 X187 - .1 X214 - .12 X241 < 0

COWCP21) 21.46 X2 + 24.48 X3 + 24.87 X4 + 25.27 X5 + 25.79 X6 + 26.44 X7 + 27.06 X8 + 27.82 X9 + 28.53 X10 + 29.37 X11 + 30.15 X12 + 31.02 X13 + 31.73 X14 + 32.60 X15 + 33.26 X16 + 33.87 X17 + 34.19 X18 + 34.16 X19 + 33.70 X20 + 30.66 X21 + 23.77 X27 + 24.13 X28 + 24.66 X29 + 25.10 X30 + 25.52 X31 + 26.05 X32 + 26.68 X33 + 27.28 X34 + 27.59 X35 + 28.50 X36 + 29.48 X37 +30.34 X38 + 31.32 X39 + 32.05 X40 + 32.92 X41 + 33.58 X42 + 34.21 X43 + 34.52 X44 + 34.50 X45 + 34.03 X46 + 30.94 X47 + 11.96 X52 + 24.94 X53 + 25.18 X54 + 25.74 X55 + 26.20 X56 + 26.69 X57 + 27.27 X58 + 27.95 X59 + 28.68 X60 + 29.48 X61 + 30.24 X62 + 31.19 X63 + 31.97 X64 + 32.95 X65 + 33.68 X66 + 34.61 X67 + 35.32 X68 + 35.94 X69 + 36.27 X70 + 36.25 X71 + 35.74 X72 + 32.51 X73 + 12.67 X78 - 0.20 X158 - 0.16 X188 - .1 X215 - .12 X242 < 0

COWCP22) 21.46 X3 + 24.48 X4 + 24.87 X5 + 25.27 X6 + 25.79 X7 + 26.44 X8 + 27.06 X9 + 27.82 X10 + 28.53 X11 + 29.37 X12 + 30.15 X13 + 31.02 X14 + 31.73 X15 + 32.60 X16 + 33.26 X17 + 33.87 X18 + 34.19 X19 + 34.16 X20 + 33.70 X21 + 30.66 X22 + 11.96 X27 + 23.77 X28 + 24.13 X29 + 24.66 X30 + 25.10 X31 + 25.52 X32 + 26.05 X33 + 26.68 X34 + 27.28 X35 + 27.59 X36 +28.50 X37 + 29.48 X38 + 30.34 X39 + 31.32 X40 + 32.05 X41 + 32.92 X42 + 33.58 X43 + 34.21 X44 + 34.52 X45 + 34.50 X46 + 34.03 X47 + 30.94 X48 + 12.67 X53 + 24.94 X54 + 25.18 X55 + 25.74 X56 + 26.20 X57 + 26.69 X58 + 27.27 X59 + 27.95 X60 + 28.68 X61 + 29.48 X62 + 30.24 X63 + 31.19 X64 + 31.97 X65 + 32.95 X66 + 33.68 X67 + 34.61 X68 + 35.32 X69 + 35.94 X70 + 36.27 X71 + 36.25 X72 + 35.74 X73 + 32.51 X74 - 0.22 X159 - 0.16 X189 - .1 X216 - .12 X243 < 0

COWCP23) 21.46 X4 + 24.48 X5 + 24.87 X6 + 25.27 X7 + 25.79 X8 + 26.44 X9 + 27.06 X10 + 27.82 X11 + 28.53 X12 + 29.37 X13 + 30.15 X14 + 31.02 X15 + 31.73 X16 + 32.60 X17 + 33.26 X18 + 33.87 X19 + 34.19 X20 + 34.16 X21 + 33.70 X22 + 30.66 X23 + 11.96 X28 + 23.77 X29 + 24.13 X30 + 24.66 X31 + 25.10 X32 + 25.52 X33 + 26.05 X34 + 26.68 X35 + 27.28 X36 + 27.59 X37 +28.50 X38 + 29.48 X39 + 30.34 X40 + 31.32 X41 + 32.05 X42 + 32.92 X43 + 33.58 X44 + 34.21 X45 + 34.52 X46 + 34.50 X47 + 34.03 X48 + 30.94 X49 + 12.67 X54 + 24.94 X55 + 25.18 X56 + 25.74 X57 + 26.20 X58 + 26.69 X59 + 27.27 X60 + 27.95 X61 + 28.68 X62 + 29.48 X63 + 30.24 X64 + 31.19 X65 + 31.97 X66 + 32.95 X67 + 33.68 X68 + 34.61 X69 + 35.32 X70 + 35.94 X71 + 36.27 X72 + 36.25 X73 + 35.74 X74 + 32.51 X75 - 0.24 X160 - 0.16 X190 - .1 X217 - .12 X244 < 0

COWCP24) 21.46 X5 + 24.48 X6 + 24.87 X7 + 25.27 X8 + 25.79 X9 + 26.44 X10 + 27.06 X11 + 27.82 X12 + 28.53 X13 + 29.37 X14 + 30.15 X15 + 31.02 X16 + 31.73 X17 + 32.60 X18 + 33.26 X19 + 33.87 X20 + 34.19 X21 + 34.16 X22 + 33.70 X23 + 30.66 X24 + 11.96 X29 + 23.77 X30 + 24.13 X31 + 24.66 X32 + 25.10 X33 + 25.52 X34 + 26.05 X35 + 26.68 X36 + 27.28 X37 + 27.59 X38 +28.50 X39 + 29.48 X40 + 30.34 X41 + 31.32 X42 + 32.05 X43 + 32.92 X44 + 33.58 X45 + 34.21 X46 + 34.52 X47 + 34.50 X48 + 34.03 X49 + 30.94 X50 + 12.67 X55 + 24.94 X56 + 25.18 X57 + 25.74 X58 + 26.20 X59 + 26.69 X60 + 27.27 X61 +27.95 X62 + 28.68 X63 + 29.48 X64 + 30.24 X65 + 31.19 X66 + 31.97 X67 + 32.95 X68 + 33.68 X69 + 34.61 X70 + 35.32 X71 + 35.94 X72 + 36.27 X73 + 36.25 X74 + 35.74 X75 + 32.51 X76 - 0.25 X161 - 0.16 X191 - .1 X218 - .12 X245 < 0

COWCP25) 21.46 X6 + 24.48 X7 + 24.87 X8 + 25.27 X9 + 25.79 X10 + 26.44 X11 + 27.06 X12 + 27.82 X13 + 28.53 X14 + 29.37 X15 + 30.15 X16 + 31.02 X17 +

31.73 X18 + 32.60 X19 + 33.26 X20 + 33.87 X21 + 34.19 X22 + 34.16 X23 + 33.70 X24 + 30.66 X25 + 11.96 X30 + 23.77 X31 +24.13 X32 + 24.66 X33 +25.10 X34 + 25.52 X35 + 26.05 X36 + 26.68 X37 + 27.28 X38 + 27.59 X39 + 28.50 X40 + 29.48 X41 + 30.34 X42 + 31.32 X43 + 32.05 X44 + 32.92 X45 + 33.58 X46 + 34.21 X47 + 34.52 X48 + 34.50 X49 + 34.03 X50 + 30.94 X51 + 12.67 X56 + 24.94 X57 + 25.18 X58 + 25.74 X59 + 26.20 X60 + 26.69 X61 + 27.27 X62 +27.95 X63 + 28.68 X64 + 29.48 X65 + 30.24 X66 + 31.19 X67 + 31.97 X68 + 32.95 X69 + 33.68 X70 + 34.61 X71 + 35.32 X72 + 35.94 X73 + 36.27 X74 + 36.25 X75 + 35.74 X76 + 32.51 X77 - 0.25 X162 - 0.16 X192 - .1 X219 - .12 X246 < 0

COWCP26) 21.46 X7 + 24.48 X8 + 24.87 X9 + 25.27 X10 + 25.79 X11 + 26.44 X12 + 27.06 X13 + 27.82 X14 + 28.53 X15 + 29.37 X16 + 30.15 X17 + 31.02 X18 + 31.73 X19 + 32.60 X20 + 33.26 X21 + 33.87 X22 + 34.19 X23 + 34.16 X24 + 33.70 X25 + 30.66 X26 + 11.96 X31 + 23.77 X32 + 24.13 X33 + 24.66 X34 +25.10 X35 + 25.52 X36 + 26.05 X37 + 26.68 X38 + 27.28 X39 + 27.59 X40 + 28.50 X41 + 29.48 X42 + 30.34 X43 + 31.32 X44 + 32.05 X45 + 32.92 X46 + 33.58 X47 + 34.21 X48 + 34.52 X49 + 34.50 X50 + 34.03 X51 + 30.94 X52 + 12.67 X57 +24.94 X58 + 25.18 X59 + 25.74 X60 + 26.20 X61 + 26.69 X62 + 27.27 X63 + 27.95 X64 + 28.68 X65 + 29.48 X66 + 30.24 X67 + 31.19 X68 + 31.97 X69 + 32.95 X70 + 33.68 X71 + 34.61 X72 + 35.32 X73 + 35.94 X74 + 36.27 X75 + 36.25 X76 + 35.74 X77 + 32.51 X78 - 0.25 X163 - 0.16 X193 - .1 X220 - .12 X247 < 0

LAND) X91 < 170

PSN04LIM) -40 X91 + X92 < 0
PSN05LIM) -40 X91 + X93 < 0
PSN06LIM) -40 X91 + X94 < 0
PSN07LIM) -40 X91 + X95 < 0
PSN08LIM) -40 X91 + X96 < 0
PSN09LIM) -40 X91 + X97 < 0
PSN10LIM) -40 X91 + X98 < 0
PSN11LIM) -40 X91 + X99 < 0
PSN12LIM) -40 X91 + X100 < 0
PSN13LIM) -40 X91 + X101 < 0
PSN14LIM) -40 X91 + X102 < 0
PSN15LIM) -40 X91 + X103 < 0
PSN16LIM) -40 X91 + X104 < 0
PSN17LIM) -40 X91 + X105 < 0
PSN18LIM) -40 X91 + X106 < 0
PSN19LIM) -40 X91 + X107 < 0
PSN20LIM) -40 X91 + X108 < 0
PSN21LIM) -40 X91 + X109 < 0
PSN22LIM) -40 X91 + X110 < 0
PSN23LIM) -40 X91 + X111 < 0

MAXANN) -200 X91 + X92 + X93 + X94 + X95 + X96 + X97 + X98 + X99 + X100 + X101 + X102 + X103 + X104 + X105 + X106 + X107 + X108 + X109 + X110 + X111 < 0

PSDM01) -98 X91 - .9 X112 + X113 + 1.15 X138 + 150 X250 + 150 X252 + 150 X254 + 150 X256 + 150 X258 + 150 X260 + 177 X302 + 177 X304 + 177 X306 + 177 X308 + 177 X354 + 177 X356 + 177 X358 + 177 X360 < 0

PSDM02) -98 X91 - .9 X113 + X114 + 1.15 X139 + 150 X252 + 150 X254 + 150 X256 + 150 X258 + 150 X260 + 150 X262 + 177 X304 + 177 X306 + 177 X308 + 177 X310 + 177 X356 + 177 X358 + 177 X360 + 177 X362 < 0

PSDM03) -186.00 X91 - .9 X114 + X115 + 1.15 X140 + 150 X254 + 150 X256 + 150 X258 + 150 X260 + 150 X262 + 150 X264 + 177 X306 + 177 X308 + 177 X310 + 177 X312 + 177 X358 + 177 X360 + 177 X362 + 177 X364 < 0

PSDM04) -210.00 X91 - X92 - .9 X115 + X116 + 1.15 X141 + 150 X256 + 150 X258 + 150 X260 + 150 X262 + 150 X264 + 150 X266 + 177 X308 + 177 X310 +

177 X312 + 177 X314 + 177 X360 + 177 X362 + 177 X364 + 177 X366 < 0

PSDM05) -290.00 X91 - 3 X92 - X93 - .9 X116 + X117 + 1.15 X142 + 150 X258 + 150 X260 + 150 X262 + 150 X264 + 150 X266 + 150 X268 + 177 X310 + 177 X312 + 177 X314 + 177 X316 + 177 X362 + 177 X364 + 177 X366 + 177 X368 < 0

PSDM06) -350.00 X91 - 3 X92 - 3 X93 - X94 - .9 X117 + X118 + 1.15 X143 + 150 X260 + 150 X262 + 150 X264 + 150 X266 + 150 X268 + 150 X270 + 177 X312 + 177 X314 + 177 X316 + 177 X318 + 177 X364 + 177 X366 + 177 X368 + 177 X370 < 0

PSDM07) -440.00 X91 - 3 X92 - 3 X93 - 3 X94 - X95 - .9 X118 + X119 + 1.15 X144 + 440 X164 + 150 X262 + 150 X264 + 150 X266 + 150 X268 + 150 X270 + 150 X272 + 177 X314 + 177 X316 + 177 X318 + 177 X320 + 177 X366 + 177 X368 + 177 X370 + 177 X372 < 0

PSDM08) -560.00 X91 - 3 X93 - 3 X94 - 3 X95 - X96 - .9 X119 + X120 + 1.15 X145 + 560 X164 + 560 X165 + 150 X264 + 150 X266 + 150 X268 + 150 X270 + 150 X272 + 150 X274 + 177 X316 + 177 X318 + 177 X320 + 177 X322 + 177 X368 + 177 X370 + 177 X372 + 177 X374 < 0

PSDM09) -590.00 X91 - 3 X94 - 3 X95 - 3 X96 - X97 - .9 X120 + X121 + 1.15 X146 + 590 X164 + 590 X165 + 590 X166 + 150 X266 + 150 X268 + 150 X270 + 150 X272 + 150 X274 + 150 X276 + 177 X318 + 177 X320 + 177 X322 + 177 X324 + 177 X370 + 177 X372 + 177 X374 + 177 X376 < 0

PSDM10) -700.00 X91 - 3 X95 - 3 X96 - 3 X97 - X98 - .9 X121 + X122 + 1.15 X147 + 2560 X164 + 700 X165 + 700 X166 + 150 X268 + 150 X270 + 150 X272 + 150 X274 + 150 X276 + 150 X278 + 177 X320 + 177 X322 + 177 X324 + 177 X326 + 177 X372 + 177 X374 + 177 X376 + 177 X378 < 0

PSDM11) -700.00 X91 - 3 X96 - 3 X97 - 3 X98 - X99 - .9 X122 + X123 + 1.15 X148 + 350 X164 + 2300 X165 + 700 X166 + 150 X270 + 150 X272 + 150 X274 + 150 X276 + 150 X278 + 150 X280 + 177 X322 + 177 X324 + 177 X326 + 177 X328 + 177 X374 + 177 X376 + 177 X378 + 177 X380 < 0

PSDM12) -700.00 X91 - 3 X97 - 3 X98 - 3 X99 - X100 - .9 X123 + X124 + 1.15 X149 + 350 X165 + 2160 X166 + 150 X272 + 150 X274 + 150 X276 + 150 X278 + 150 X280 + 150 X282 + 177 X324 + 177 X326 + 177 X328 + 177 X330 + 177 X376 + 177 X378 + 177 X380 + 177 X382 < 0

PSDM13) -700.00 X91 - 3 X98 - 3 X99 - 3 X100 - X101 - .9 X124 + X125 + 1.15 X150 + 350 X166 + 150 X274 + 150 X276 + 150 X278 + 150 X280 + 150 X282 + 150 X284 + 177 X326 + 177 X328 + 177 X330 + 177 X332 + 177 X378 + 177 X380 + 177 X382 + 177 X384 < 0

PSDM14) -676.00 X91 - 3 X99 - 3 X100 - 3 X101 - X102 - .9 X125 + X126 + 1.15 X151 + 150 X276 + 150 X278 + 150 X280 + 150 X282 + 150 X284 + 150 X286 + 177 X328 + 177 X330 + 177 X332 + 177 X334 + 177 X380 + 177 X380 + 177 X382 + 177 X384 + 177 X386 < 0

PSDM15) -672.00 X91 - 3 X100 - 3 X101 - 3 X102 - X103 - .9 X126 + X127 + 1.15 X152 + 150 X278 + 150 X280 + 150 X282 + 150 X284 + 150 X286 + 150 X288 + 177 X330 + 177 X332 + 177 X334 + 177 X336 + 177 X382 + 177 X384 + 177 X386 + 177 X388 < 0

PSDM16) -645.00 X91 - 3 X101 - 3 X102 - 3 X103 - X104 - .9 X127 + X128 + 1.15 X153 + 150 X280 + 150 X282 + 150 X284 + 150 X286 + 150 X288 + 150 X290 + 177 X332 + 177 X334 + 177 X336 + 177 X338 + 177 X384 + 177 X386 + 177 X388 + 177 X390 < 0

PSDM17) -630.00 X91 - 3 X102 - 3 X103 - 3 X104 - X105 - .9 X128 + X129 + 1.15 X154 + 150 X282 + 150 X284 + 150 X286 + 150 X288 + 150 X290 + 150 X292 + 177 X334 + 177 X336 + 177 X338 + 177 X340 + 177 X386 + 177 X388 + 177 X390 + 177 X392 < 0

PSDM18) -553.00 X91 - 3 X103 - 3 X104 - 3 X105 - X106 - .9 X129 + X130 + 1.15 X155 + 150 X284 + 150 X286 + 150 X288 + 150 X290 + 150 X292 + 150 X294 + 177 X336 + 177 X338 + 177 X340 + 177 X342 + 177 X388 + 177 X390 + 177 X392 + 177 X394 < 0

PSDM19) -574.00 X91 - 3 X104 - 3 X105 - 3 X106 - X107 - .9 X130 + X131 + 1.15 X156 + 150 X286 + 150 X288 + 150 X290 + 150 X292 + 150 X294 + 150 X296 + 177 X338 + 177 X340 + 177 X342 + 177 X344 + 177 X390 + 177 X392 + 177 X394 + 177 X396 < 0

PSDM20) -519.00 X91 - 3 X105 - 3 X106 - 3 X107 - X108 - .9 X131 + X132 + 1.15 X157 + 150 X288 + 150 X290 + 150 X292 + 150 X294 + 150 X296 + 150 X298 + 177 X340 + 177 X342 + 177 X344 + 177 X346 + 177 X392 + 177 X394 + 177 X396 + 177 X398 < 0

PSDM21) -420.00 X91 - 3 X106 - 3 X107 - 3 X108 - X109 - .9 X132 + X133 + 1.15 X158 + 150 X248 + 150 X290 + 150 X292 + 150 X294 + 150 X296 + 150 X298 + 177 X342 + 177 X344 + 177 X346 + 177 X348 + 177 X394 + 177 X396 + 177 X398 + 177 X400 < 0

PSDM22) -390.00 X91 - 3 X107 - 3 X108 - 3 X109 - X110 - .9 X133 + X134 + 1.15 X159 + 150 X248 + 150 X250 + 150 X292 + 150 X294 + 150 X296 + 150 X298 + 177 X344 + 177 X346 + 177 X348 + 177 X350 + 177 X396 + 177 X398 + 177 X400 + 177 X402 < 0

PSDM23) -280.00 X91 - 3 X108 - 3 X109 - 3 X110 - X111 - .9 X134 + X135 + 1.15 X160 + 150 X248 + 150 X250 + 150 X252 + 150 X294 + 150 X296 + 150 X298 + 177 X300 + 177 X346 + 177 X348 + 177 X350 + 177 X352 + 177 X398 + 177 X400 + 177 X402 < 0

PSDM24) -280.00 X91 - 3 X109 - 3 X110 - 3 X111 - .9 X135 + X136 + 1.15 X161 + 150 X248 + 150 X250 + 150 X252 + 150 X254 + 150 X296 + 150 X298 + 177 X300 + 177 X302 + 177 X348 + 177 X350 + 177 X352 + 177 X354 + 177 X400 + 177 X402 < 0

PSDM25) -70 X91 - 3 X110 - 3 X111 - .9 X136 + X137 + 1.15 X162 + 150 X248 + 150 X250 + 150 X252 + 150 X254 + 150 X256 + 150 X298 + 177 X300 + 177 X302 + 177 X304 + 177 X350 + 177 X352 + 177 X354 + 177 X356 + 177 X402 < 0

PSDM26) -80 X91 - 3 X111 - .9 X137 + X112 + 1.15 X163 + 150 X248 + 150 X250 + 150 X252 + 150 X254 + 150 X256 + 150 X258 + 150 X300 + 177 X302 + 177 X304 + 177 X306 + 177 X352 + 177 X354 + 177 X356 + 177 X358 < 0

C01MAX) -430.00 X91 + X112 < 0

C02MAX) -248.00 X91 + X113 < 0

C03MAX) -276.00 X91 + X114 < 0

C04MAX) -382.00 X91 + X115 < 0

C05MAX) -494.00 X91 + X116 < 0

C06MAX) -290.00 X91 + X117 < 0

C07MAX) -350.00 X91 + X118 < 0

C08MAX) -440.00 X91 + X119 < 0

C09MAX) -560.00 X91 + X120 < 0

C010MAX) -590.00 X91 + X121 < 0

C011MAX) -700.00 X91 + X122 < 0

C012MAX) -700.00 X91 + X123 < 0

C013MAX) -700.00 X91 + X124 < 0

C014MAX) -700.00 X91 + X125 < 0

C015MAX) -676.00 X91 + X126 < 0

C016MAX) -672.00 X91 + X127 < 0

C017MAX) -645.00 X91 + X128 < 0

C018MAX) -630.00 X91 + X129 < 0

C019MAX) -553.00 X91 + X130 < 0

C020MAX) -1127.00 X91 + X131 < 0

C021MAX) -1093.00 X91 + X132 < 0
C022MAX) -939.00 X91 + X133 < 0
C023MAX) -810.00 X91 + X134 < 0
C024MAX) -670.00 X91 + X135 < 0
C025MAX) -560.00 X91 + X136 < 0
C026MAX) -350.00 X91 + X137 < 0

PASTSIL) -4500 X164 - 4500 X165 - 4500 X166 - X167 + 1.20 X168 + 1.20 X169 + 1.20 X170 + 1.20 X171 + 1.20 X172 + 1.20 X173 + 1.20 X174 + 1.20 X175 + 1.20 X176 + 1.20 X177 + 1.20 X178 + 1.20 X179 + 1.20 X180 + 1.20 X181 + 1.20 X182 + 1.20 X183 + 1.20 X184 + 1.20 X185 + 1.20 X186 + 1.20 X187 + 1.20 X188 + 1.20 X189 + 1.20 X190 + 1.20 X191 + 1.20 X192 + 1.20 X193 < 0

BARGRDM) -X194 + 1.05 X195 + 1.05 X196 + 1.05 X197 + 1.05 X198 + 1.05 X199 + 1.05 X200 + 1.05 X201 + 1.05 X202 + 1.05 X203 + 1.05 X204 + 1.05 X205 + 1.05 X206 + 1.05 X207 + 1.05 X208 + 1.05 X209 + 1.05 X210 + 1.05 X211 + 1.05 X212 + 1.05 X213 + 1.05 X214 + 1.05 X215 + 1.05 X216 + 1.05 X217 + 1.05 X218 + 1.05 X219 + 1.05 X220 < 0

WCROPSIL) -X221 + 1.20 X222 + 1.20 X223 + 1.20 X224 + 1.20 X225 + 1.20 X226 + 1.20 X227 + 1.20 X228 + 1.20 X229 + 1.20 X230 + 1.20 X231 + 1.20 X232 + 1.20 X233 + 1.20 X234 + 1.20 X235 + 1.20 X236 + 1.20 X237 + 1.20 X238 + 1.20 X239 + 1.20 X240 + 1.20 X241 + 1.20 X242 + 1.20 X243 + 1.20 X244 + 1.20 X245 + 1.20 X246 + 1.20 X247 < 0

DRYMEC01)9800 X1 - 9800 X248 - 9800 X249 - 8.5 X405 < 0
DRYMEC02)9800 X2 - 9800 X250 - 9800 X251 - 8.5 X406 < 0
DRYMEC03)9800 X3 - 9800 X252 - 9800 X253 - 8.5 X407 < 0
DRYMEC04)9800 X4 - 9800 X254 - 9800 X255 - 8.5 X408 < 0
DRYMEC05)9800 X5 - 9800 X256 - 9800 X257 - 8.5 X409 < 0
DRYMEC06)9800 X6 - 9800 X258 - 9800 X259 - 8.5 X410 < 0
DRYMEC07)9800 X7 - 9800 X260 - 9800 X261 - 8.5 X411 < 0
DRYMEC08)9800 X8 - 9800 X262 - 9800 X263 - 8.5 X412 < 0
DRYMEC09)9800 X9 - 9800 X264 - 9800 X265 - 8.5 X413 < 0
DRYMEC10)9800 X10 - 9800 X266 - 9800 X267 - 8.5 X414 < 0
DRYMEC11)9800 X11 - 9800 X268 - 9800 X269 - 8.5 X415 < 0
DRYMEC12)9800 X12 - 9800 X270 - 9800 X271 - 8.5 X416 < 0
DRYMEC13)9800 X13 - 9800 X272 - 9800 X273 - 8.5 X417 < 0
DRYMEC14)9800 X14 - 9800 X274 - 9800 X275 - 8.5 X418 < 0
DRYMEC15)9800 X15 - 9800 X276 - 9800 X277 - 8.5 X419 < 0
DRYMEC16)9800 X16 - 9800 X278 - 9800 X279 - 8.5 X420 < 0
DRYMEC17)9800 X17 - 9800 X280 - 9800 X281 - 8.5 X421 < 0
DRYMEC18)9800 X18 - 9800 X282 - 9800 X283 - 8.5 X422 < 0
DRYMEC19)9800 X19 - 9800 X284 - 9800 X285 - 8.5 X423 < 0
DRYMEC20)9800 X20 - 9800 X286 - 9800 X287 - 8.5 X424 < 0
DRYMEC21)9800 X21 - 9800 X288 - 9800 X289 - 8.5 X425 < 0
DRYMEC22)9800 X22 - 9800 X290 - 9800 X291 - 8.5 X426 < 0
DRYMEC23)9800 X23 - 9800 X292 - 9800 X293 - 8.5 X427 < 0
DRYMEC24)9800 X24 - 9800 X294 - 9800 X295 - 8.5 X428 < 0
DRYMEC25)9800 X25 - 9800 X296 - 9800 X297 - 8.5 X429 < 0
DRYMEC26)9800 X26 - 9800 X298 - 9800 X299 - 8.5 X430 < 0
DRYMEC27)6800 X27 - 6800 X300 - 6800 X301 - 8.5 X431 < 0
DRYMEC28)6800 X28 - 6800 X302 - 6800 X303 - 8.5 X432 < 0
DRYMEC29)6800 X29 - 6800 X304 - 6800 X305 - 8.5 X433 < 0
DRYMEC30)6800 X30 - 6800 X306 - 6800 X307 - 8.5 X434 < 0
DRYMEC31)6800 X31 - 6800 X308 - 6800 X309 - 8.5 X435 < 0
DRYMEC32)6800 X32 - 6800 X310 - 6800 X311 - 8.5 X436 < 0
DRYMEC33)6800 X33 - 6800 X312 - 6800 X313 - 8.5 X437 < 0
DRYMEC34)6800 X34 - 6800 X314 - 6800 X315 - 8.5 X438 < 0
DRYMEC35)6800 X35 - 6800 X316 - 6800 X317 - 8.5 X439 < 0
DRYMEC36)6800 X36 - 6800 X318 - 6800 X319 - 8.5 X440 < 0
DRYMEC37)6800 X37 - 6800 X320 - 6800 X321 - 8.5 X441 < 0
DRYMEC38)6800 X38 - 6800 X322 - 6800 X323 - 8.5 X442 < 0

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DRYMEC39)6800 X39 - 6800 X324 - 6800 X325 - 8.5 X443 < 0
DRYMEC40)6800 X40 - 6800 X326 - 6800 X327 - 8.5 X444 < 0
DRYMEC41)6800 X41 - 6800 X328 - 6800 X329 - 8.5 X445 < 0
DRYMEC42)6800 X42 - 6800 X330 - 6800 X331 - 8.5 X446 < 0
DRYMEC43)6800 X43 - 6800 X332 - 6800 X333 - 8.5 X447 < 0
DRYMEC44)6800 X44 - 6800 X334 - 6800 X335 - 8.5 X448 < 0
DRYMEC45)6800 X45 - 6800 X336 - 6800 X337 - 8.5 X449 < 0
DRYMEC46)6800 X46 - 6800 X338 - 6800 X339 - 8.5 X450 < 0
DRYMEC47)6800 X47 - 6800 X340 - 6800 X341 - 8.5 X451 < 0
DRYMEC48)6800 X48 - 6800 X342 - 6800 X343 - 8.5 X452 < 0
DRYMEC49)6800 X49 - 6800 X344 - 6800 X345 - 8.5 X453 < 0
DRYMEC50)6800 X50 - 6800 X346 - 6800 X347 - 8.5 X454 < 0
DRYMEC51)6800 X51 - 6800 X348 - 6800 X349 - 8.5 X455 < 0
DRYMEC52)6800 X52 - 6800 X350 - 6800 X351 - 8.5 X456 < 0
DRYMEC53)6800 X53 - 6800 X352 - 6800 X353 - 8.5 X457 < 0
DRYMEC54)6800 X54 - 6800 X354 - 6800 X355 - 8.5 X458 < 0
DRYMEC55)6800 X55 - 6800 X356 - 6800 X357 - 8.5 X459 < 0
DRYMEC56)6800 X56 - 6800 X358 - 6800 X359 - 8.5 X460 < 0
DRYMEC57)6800 X57 - 6800 X360 - 6800 X361 - 8.5 X461 < 0
DRYMEC58)6800 X58 - 6800 X362 - 6800 X363 - 8.5 X462 < 0
DRYMEC59)6800 X59 - 6800 X364 - 6800 X365 - 8.5 X463 < 0
DRYMEC60)6800 X60 - 6800 X366 - 6800 X367 - 8.5 X464 < 0
DRYMEC61)6800 X61 - 6800 X368 - 6800 X369 - 8.5 X465 < 0
DRYMEC62)6800 X62 - 6800 X370 - 6800 X371 - 8.5 X466 < 0
DRYMEC63)6800 X63 - 6800 X372 - 6800 X373 - 8.5 X467 < 0
DRYMEC64)6800 X64 - 6800 X374 - 6800 X375 - 8.5 X468 < 0
DRYMEC65)6800 X65 - 6800 X376 - 6800 X377 - 8.5 X469 < 0
DRYMEC66)6800 X66 - 6800 X378 - 6800 X379 - 8.5 X470 < 0
DRYMEC67)6800 X67 - 6800 X380 - 6800 X381 - 8.5 X471 < 0
DRYMEC68)6800 X68 - 6800 X382 - 6800 X383 - 8.5 X472 < 0
DRYMEC69)6800 X69 - 6800 X384 - 6800 X385 - 8.5 X473 < 0
DRYMEC70)6800 X70 - 6800 X386 - 6800 X387 - 8.5 X474 < 0
DRYMEC71)6800 X71 - 6800 X388 - 6800 X389 - 8.5 X475 < 0
DRYMEC72)6800 X72 - 6800 X390 - 6800 X391 - 8.5 X476 < 0
DRYMEC73)6800 X73 - 6800 X392 - 6800 X393 - 8.5 X477 < 0
DRYMEC74)6800 X74 - 6800 X394 - 6800 X395 - 8.5 X478 < 0
DRYMEC75)6800 X75 - 6800 X396 - 6800 X397 - 8.5 X479 < 0
DRYMEC76)6800 X76 - 6800 X398 - 6800 X399 - 8.5 X480 < 0
DRYMEC77)6800 X77 - 6800 X400 - 6800 X401 - 8.5 X481 < 0
DRYMEC78)6800 X78 - 6800 X402 - 6800 X403 - 8.5 X482 < 0

HAYREC) -X404 + 1.2 X405 + 1.2 X406 + 1.2 X407 + 1.2 X408 + 1.2 X409 + 1.2
X410 + 1.2 X411 + 1.2 X412 + 1.2 X413 + 1.2 X414 + 1.2 X415 + 1.2 X416 +
1.2 X417 + 1.2 X418 + 1.2 X419 + 1.2 X420 + 1.2 X421 + 1.2 X422 + 1.2 X423
+ 1.2 X424 + 1.2 X425 + 1.2 X426 + 1.2 X427 + 1.2 X428 + 1.2 X429 + 1.2
X430 + 1.2 X431 + 1.2 X432 + 1.2 X433 + 1.2 X434 + 1.2 X435 + 1.2 X436 +
1.2 X437 + 1.2 X438 + 1.2 X439 + 1.2 X440 + 1.2 X441 + 1.2 X442 + 1.2 X443
+ 1.2 X444 + 1.2 X445 + 1.2 X446 + 1.2 X447 + 1.2 X448 + 1.2 X449 + 1.2
X450 + 1.2 X451 + 1.2 X452 + 1.2 X453 + 1.2 X454 + 1.2 X455 + 1.2 X456 +
1.2 X457 + 1.2 X458 + 1.2 X459 + 1.2 X460 + 1.2 X461 + 1.2 X462 + 1.2 X463
+ 1.2 X464 + 1.2 X465 + 1.2 X466 + 1.2 X467 + 1.2 X468 + 1.2 X469 + 1.2
X470 + 1.2 X471 + 1.2 X472 + 1.2 X473 + 1.2 X474 + 1.2 X475 + 1.2 X476 +
1.2 X477 + 1.2 X478 + 1.2 X479 + 1.2 X480 + 1.2 X481 + 1.2 X482 < 0

MAXSR) -4 X91 + X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 + X9 + X10 + X11 +
X12 + X13 + X14 + X15 + X16 + X17 + X18 + X19 + X20 + X21 + X22 + X23 + X24
+ X25 + X26 + X27 + X28 + X29 + X30 + X31 + X32 + X33 + X34 + X35 + X36 +
X37 + X38 + X39 + X40 + X41 + X42 + X43 + X44 + X45 + X46 + X47 + X48 + X49
+ X50 + X51 + X52 + X53 + X54 + X55 + X56 + X57 + X58 + X59 + X60 + X61 +
X62 + X63 + X64 + X65 + X66 + X67 + X68 + X69 + X70 + X71 + X72 + X73 + X74
+ X75 + X76 + X77 + X78 < 0

END
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List of Variable Definitions

COW ACTIVITIES

X1 = cow calving on 1 July, producing 370 kg MS with a 270-day lactation (1 cow),
X2 = cow calving on 15 July, producing 370 kg MS with a 270-day lactation (1 cow),
X3 = cow calving on 29 July, producing 370 kg MS with a 270-day lactation (1 cow),
X4 = cow calving on 12 August, producing 370 kg MS with a 270-day lactation (1 cow),
X5 = cow calving on 26 August, producing 370 kg MS with a 270-day lactation (1 cow),
X6 = cow calving on 9 September, producing 370 kg MS with a 270-day lactation (1 cow),
X7 = cow calving on 23 September, producing 370 kg MS with a 270-day lactation (1 cow),
X8 = cow calving on 7 October, producing 370 kg MS with a 270-day lactation (1 cow),
X9 = cow calving on 21 October, producing 370 kg MS with a 270-day lactation (1 cow),
X10 = cow calving on 4 November, producing 370 kg MS with a 270-day lactation (1 cow),
X11 = cow calving on 18 November, producing 370 kg MS with a 270-day lactation (1 cow),
X12 = cow calving on 2 December, producing 370 kg MS with a 270-day lactation (1 cow),
X13 = cow calving on 16 December, producing 370 kg MS with a 270-day lactation (1 cow),
X14 = cow calving on 30 December, producing 370 kg MS with a 270-day lactation (1 cow),
X15 = cow calving on 13 January, producing 370 kg MS with a 270-day lactation (1 cow),
X16 = cow calving on 27 January, producing 370 kg MS with a 270-day lactation (1 cow),
X17 = cow calving on 10 February, producing 370 kg MS with a 270-day lactation (1 cow),
X18 = cow calving on 24 February, producing 370 kg MS with a 270-day lactation (1 cow),
X19 = cow calving on 10 March, producing 370 kg MS with a 270-day lactation (1 cow),
X20 = cow calving on 24 March, producing 370 kg MS with a 270-day lactation (1 cow),
X21 = cow calving on 7 April, producing 370 kg MS with a 270-day lactation (1 cow),
X22 = cow calving on 21 April, producing 370 kg MS with a 270-day lactation (1 cow),
X23 = cow calving on 5 May, producing 370 kg MS with a 270-day lactation (1 cow),
X24 = cow calving on 19 May, producing 370 kg MS with a 270-day lactation (1 cow),
X25 = cow calving on 2 June, producing 370 kg MS with a 270-day lactation (1 cow),
X26 = cow calving on 16 June, producing 370 kg MS with a 270-day lactation (1 cow),
X27 = cow calving on 1 July, producing 400 kg MS with a 300-day lactation (1 cow),
X28 = cow calving on 15 July, producing 400 kg MS with a 300-day lactation (1 cow),
X29 = cow calving on 29 July, producing 400 kg MS with a 300-day lactation (1 cow),
X30 = cow calving on 12 August, producing 400 kg MS with a 300-day lactation (1 cow),
X31 = cow calving on 26 August, producing 400 kg MS with a 300-day lactation (1 cow),
X32 = cow calving on 9 September, producing 400 kg MS with a 300-day lactation (1 cow),
X33 = cow calving on 23 September, producing 400 kg MS with a 300-day lactation (1 cow),
X34 = cow calving on 7 October, producing 400 kg MS with a 300-day lactation (1 cow),
X35 = cow calving on 21 October, producing 400 kg MS with a 300-day lactation (1 cow),
X36 = cow calving on 4 November, producing 400 kg MS with a 300-day lactation (1 cow),
X37 = cow calving on 18 November, producing 400 kg MS with a 300-day lactation (1 cow),
X38 = cow calving on 2 December, producing 400 kg MS with a 300-day lactation (1 cow),
X39 = cow calving on 16 December, producing 400 kg MS with a 300-day lactation (1 cow),
X40 = cow calving on 30 December, producing 400 kg MS with a 300-day lactation (1 cow),
X41 = cow calving on 13 January, producing 400 kg MS with a 300-day lactation (1 cow),
X42 = cow calving on 27 January, producing 400 kg MS with a 300-day lactation (1 cow),
X43 = cow calving on 10 February, producing 400 kg MS with a 300-day lactation (1 cow),
X44 = cow calving on 24 February, producing 400 kg MS with a 300-day lactation (1 cow),
X45 = cow calving on 10 March, producing 400 kg MS with a 300-day lactation (1 cow),
X46 = cow calving on 24 March, producing 400 kg MS with a 300-day lactation (1 cow),
X47 = cow calving on 7 April, producing 400 kg MS with a 300-day lactation (1 cow),
X48 = cow calving on 21 April, producing 400 kg MS with a 300-day lactation (1 cow),

X49 = cow calving on 5 May, producing 400 kg MS with a 300-day lactation (1 cow),
X50 = cow calving on 19 May, producing 400 kg MS with a 300-day lactation (1 cow),
X51 = cow calving on 2 June, producing 400 kg MS with a 300-day lactation (1 cow),
X52 = cow calving on 16 June, producing 400 kg MS with a 300-day lactation (1 cow),
X53 = cow calving on 1 July, producing 430 kg MS with a 300-day lactation (1 cow),
X54 = cow calving on 15 July, producing 430 kg MS with a 300-day lactation (1 cow),
X55 = cow calving on 29 July, producing 430 kg MS with a 300-day lactation (1 cow),
X56 = cow calving on 12 August, producing 430 kg MS with a 300-day lactation (1 cow),
X57 = cow calving on 26 August, producing 430 kg MS with a 300-day lactation (1 cow),
X58 = cow calving on 9 September, producing 430 kg MS with a 300-day lactation (1 cow),
X59 = cow calving on 23 September, producing 430 kg MS with a 300-day lactation (1 cow),
X60 = cow calving on 7 October, producing 430 kg MS with a 300-day lactation (1 cow),
X61 = cow calving on 21 October, producing 430 kg MS with a 300-day lactation (1 cow),
X62 = cow calving on 4 November, producing 430 kg MS with a 300-day lactation (1 cow),
X63 = cow calving on 18 November, producing 430 kg MS with a 300-day lactation (1 cow),
X64 = cow calving on 2 December, producing 430 kg MS with a 300-day lactation (1 cow),
X65 = cow calving on 16 December, producing 430 kg MS with a 300-day lactation (1 cow),
X66 = cow calving on 30 December, producing 430 kg MS with a 300-day lactation (1 cow),
X67 = cow calving on 13 January, producing 430 kg MS with a 300-day lactation (1 cow),
X68 = cow calving on 27 January, producing 430 kg MS with a 300-day lactation (1 cow),
X69 = cow calving on 10 February, producing 430 kg MS with a 300-day lactation (1 cow),
X70 = cow calving on 24 February, producing 430 kg MS with a 300-day lactation (1 cow),
X71 = cow calving on 10 March, producing 430 kg MS with a 300-day lactation (1 cow),
X72 = cow calving on 24 March, producing 430 kg MS with a 300-day lactation (1 cow),
X73 = cow calving on 7 April, producing 430 kg MS with a 300-day lactation (1 cow),
X74 = cow calving on 21 April, producing 430 kg MS with a 300-day lactation (1 cow),
X75 = cow calving on 5 May, producing 430 kg MS with a 300-day lactation (1 cow),
X76 = cow calving on 19 May, producing 430 kg MS with a 300-day lactation (1 cow),
X77 = cow calving on 2 June, producing 430 kg MS with a 300-day lactation (1 cow),
X78 = cow calving on 16 June, producing 430 kg MS with a 300-day lactation (1 cow),

MILK SELLING ACTIVITIES

X79 = sell milk in July (kg MS),
X80 = sell milk in August (kg MS),
X81 = sell milk in September (kg MS),
X82 = sell milk in October (kg MS),
X83 = sell milk in November (kg MS),
X84 = sell milk in December (kg MS),
X85 = sell milk in January (kg MS),
X86 = sell milk in February (kg MS),
X87 = sell milk in March (kg MS),
X88 = sell milk in April (kg MS),
X89 = sell milk in May (kg MS),
X90 = sell milk in June (kg MS),

PASTURE GROWING ACTIVITY

X91 = grow pasture (ha),

NITROGEN APPLICATION ACTIVITIES

X92 = apply nitrogen fertilizer in period 4 (kg),
X93 = apply nitrogen fertilizer in period 5 (kg),

X94 = apply nitrogen fertilizer in period 6 (kg),
X95 = apply nitrogen fertilizer in period 7 (kg),
X96 = apply nitrogen fertilizer in period 8 (kg),
X97 = apply nitrogen fertilizer in period 9 (kg),
X98 = apply nitrogen fertilizer in period 10 (kg),
X99 = apply nitrogen fertilizer in period 11 (kg),
X100 = apply nitrogen fertilizer in period 12 (kg),
X101 = apply nitrogen fertilizer in period 13 (kg),
X102 = apply nitrogen fertilizer in period 14 (kg),
X103 = apply nitrogen fertilizer in period 15 (kg),
X104 = apply nitrogen fertilizer in period 16 (kg),
X105 = apply nitrogen fertilizer in period 17 (kg),
X106 = apply nitrogen fertilizer in period 18 (kg),
X107 = apply nitrogen fertilizer in period 19 (kg),
X108 = apply nitrogen fertilizer in period 20 (kg),
X109 = apply nitrogen fertilizer in period 21 (kg),
X110 = apply nitrogen fertilizer in period 22 (kg),
X111 = apply nitrogen fertilizer in period 23 (kg),

IN-SITU PASTURE TRANSFER ACTIVITIES

X112 = transfer pasture from period 26 to period 1 (kg DM),
X113 = transfer pasture from period 1 to period 2 (kg DM),
X114 = transfer pasture from period 2 to period 3 (kg DM),
X115 = transfer pasture from period 3 to period 4 (kg DM),
X116 = transfer pasture from period 4 to period 5 (kg DM),
X117 = transfer pasture from period 5 to period 6 (kg DM),
X118 = transfer pasture from period 6 to period 7 (kg DM),
X119 = transfer pasture from period 7 to period 8 (kg DM),
X120 = transfer pasture from period 8 to period 9 (kg DM),
X121 = transfer pasture from period 9 to period 10 (kg DM),
X122 = transfer pasture from period 10 to period 11 (kg DM),
X123 = transfer pasture from period 11 to period 12 (kg DM),
X124 = transfer pasture from period 12 to period 13 (kg DM),
X125 = transfer pasture from period 13 to period 14 (kg DM),
X126 = transfer pasture from period 14 to period 15 (kg DM),
X127 = transfer pasture from period 15 to period 16 (kg DM),
X128 = transfer pasture from period 16 to period 17 (kg DM),
X129 = transfer pasture from period 17 to period 18 (kg DM),
X130 = transfer pasture from period 18 to period 19 (kg DM),
X131 = transfer pasture from period 19 to period 20 (kg DM),
X132 = transfer pasture from period 20 to period 21 (kg DM),
X133 = transfer pasture from period 21 to period 22 (kg DM),
X134 = transfer pasture from period 22 to period 23 (kg DM),
X135 = transfer pasture from period 23 to period 24 (kg DM),
X136 = transfer pasture from period 24 to period 25 (kg DM),
X137 = transfer pasture from period 25 to period 26 (kg DM),

PASTURE GRAZING ACTIVITIES (BY LACTATING COWS)

X138 = graze pasture in period 1 (kg DM),
X139 = graze pasture in period 2 (kg DM),
X140 = graze pasture in period 3 (kg DM),

X141 = graze pasture in period 4 (kg DM),
X142 = graze pasture in period 5 (kg DM),
X143 = graze pasture in period 6 (kg DM),
X144 = graze pasture in period 7 (kg DM),
X145 = graze pasture in period 8 (kg DM),
X146 = graze pasture in period 9 (kg DM),
X147 = graze pasture in period 10 (kg DM),
X148 = graze pasture in period 11 (kg DM),
X149 = graze pasture in period 12 (kg DM),
X150 = graze pasture in period 13 (kg DM),
X151 = graze pasture in period 14 (kg DM),
X152 = graze pasture in period 15 (kg DM),
X153 = graze pasture in period 16 (kg DM),
X154 = graze pasture in period 17 (kg DM),
X155 = graze pasture in period 18 (kg DM),
X156 = graze pasture in period 19 (kg DM),
X157 = graze pasture in period 20 (kg DM),
X158 = graze pasture in period 21 (kg DM),
X159 = graze pasture in period 22 (kg DM),
X160 = graze pasture in period 23 (kg DM),
X161 = graze pasture in period 24 (kg DM),
X162 = graze pasture in period 25 (kg DM),
X163 = graze pasture in period 26 (kg DM),

PASTURE SILAGE MAKING ACTIVITIES

X164 = make pasture silage in period 11 (ha),
X165 = make pasture silage in period 12 (ha),
X166 = make pasture silage in period 13 (ha),

PASTURE SILAGE BUYING ACTIVITY

X167 = buy pasture silage (kg DM),

PASTURE SILAGE FEEDING ACTIVITIES (TO LACTATING COWS)

X168 = feed pasture silage in period 1 (kg DM),
X169 = feed pasture silage in period 2 (kg DM),
X170 = feed pasture silage in period 3 (kg DM),
X171 = feed pasture silage in period 4 (kg DM),
X172 = feed pasture silage in period 5 (kg DM),
X173 = feed pasture silage in period 6 (kg DM),
X174 = feed pasture silage in period 7 (kg DM),
X175 = feed pasture silage in period 8 (kg DM),
X176 = feed pasture silage in period 9 (kg DM),
X177 = feed pasture silage in period 10 (kg DM),
X178 = feed pasture silage in period 11 (kg DM),
X179 = feed pasture silage in period 12 (kg DM),
X180 = feed pasture silage in period 13 (kg DM),
X181 = feed pasture silage in period 14 (kg DM),
X182 = feed pasture silage in period 15 (kg DM),
X183 = feed pasture silage in period 16 (kg DM),
X184 = feed pasture silage in period 17 (kg DM),
X185 = feed pasture silage in period 18 (kg DM),

X186 = feed pasture silage in period 19 (kg DM),
X187 = feed pasture silage in period 20 (kg DM),
X188 = feed pasture silage in period 21 (kg DM),
X189 = feed pasture silage in period 22 (kg DM),
X190 = feed pasture silage in period 23 (kg DM),
X191 = feed pasture silage in period 24 (kg DM),
X192 = feed pasture silage in period 25 (kg DM),
X193 = feed pasture silage in period 26 (kg DM),

BARLEY GRAIN BUYING ACTIVITY

X194 = buy barley grain (kg DM),

BARLEY GRAIN FEEDING ACTIVITIES (TO LACTATING COWS)

X195 = feed barley grain in period 1 (kg DM),
X196 = feed barley grain in period 2 (kg DM),
X197 = feed barley grain in period 3 (kg DM),
X198 = feed barley grain in period 4 (kg DM),
X199 = feed barley grain in period 5 (kg DM),
X200 = feed barley grain in period 6 (kg DM),
X201 = feed barley grain in period 7 (kg DM),
X202 = feed barley grain in period 8 (kg DM),
X203 = feed barley grain in period 9 (kg DM),
X204 = feed barley grain in period 10 (kg DM),
X205 = feed barley grain in period 11 (kg DM),
X206 = feed barley grain in period 12 (kg DM),
X207 = feed barley grain in period 13 (kg DM),
X208 = feed barley grain in period 14 (kg DM),
X209 = feed barley grain in period 15 (kg DM),
X210 = feed barley grain in period 16 (kg DM),
X211 = feed barley grain in period 17 (kg DM),
X212 = feed barley grain in period 18 (kg DM),
X213 = feed barley grain in period 19 (kg DM),
X214 = feed barley grain in period 20 (kg DM),
X215 = feed barley grain in period 21 (kg DM),
X216 = feed barley grain in period 22 (kg DM),
X217 = feed barley grain in period 23 (kg DM),
X218 = feed barley grain in period 24 (kg DM),
X219 = feed barley grain in period 25 (kg DM),
X220 = feed barley grain in period 26 (kg DM),

WHOLE CROP CEREAL SILAGE BUYING ACTIVITY

X221 = buy whole crop cereal silage (kg DM),

WHOLE CROP CEREAL SILAGE FEEDING ACTIVITIES (TO LACTATING COWS)

X222 = feed whole crop cereal silage in period 1 (kg DM),
X223 = feed whole crop cereal silage in period 2 (kg DM),
X224 = feed whole crop cereal silage in period 3 (kg DM),
X225 = feed whole crop cereal silage in period 4 (kg DM),
X226 = feed whole crop cereal silage in period 5 (kg DM),
X227 = feed whole crop cereal silage in period 6 (kg DM),

X228 = feed whole crop cereal silage in period 7 (kg DM),
X229 = feed whole crop cereal silage in period 8 (kg DM),
X230 = feed whole crop cereal silage in period 9 (kg DM),
X231 = feed whole crop cereal silage in period 10 (kg DM),
X232 = feed whole crop cereal silage in period 11 (kg DM),
X233 = feed whole crop cereal silage in period 12 (kg DM),
X234 = feed whole crop cereal silage in period 13 (kg DM),
X235 = feed whole crop cereal silage in period 14 (kg DM),
X236 = feed whole crop cereal silage in period 15 (kg DM),
X237 = feed whole crop cereal silage in period 16 (kg DM),
X238 = feed whole crop cereal silage in period 17 (kg DM),
X239 = feed whole crop cereal silage in period 18 (kg DM),
X240 = feed whole crop cereal silage in period 19 (kg DM),
X241 = feed whole crop cereal silage in period 20 (kg DM),
X242 = feed whole crop cereal silage in period 21 (kg DM),
X243 = feed whole crop cereal silage in period 22 (kg DM),
X244 = feed whole crop cereal silage in period 23 (kg DM),
X245 = feed whole crop cereal silage in period 24 (kg DM),
X246 = feed whole crop cereal silage in period 25 (kg DM),
X247 = feed whole crop cereal silage in period 26 (kg DM),

<u>GRAZING ON ACTIVITIES (DRY COWS)</u>

X248 = graze cow 1 on the farm during the dry period (head),
X250 = graze cow 2 on the farm during the dry period (head),
X252 = graze cow 3 on the farm during the dry period (head),
X254 = graze cow 4 on the farm during the dry period (head),
X256 = graze cow 5 on the farm during the dry period (head),
X258 = graze cow 6 on the farm during the dry period (head),
X260 = graze cow 7 on the farm during the dry period (head),
X262 = graze cow 8 on the farm during the dry period (head),
X264 = graze cow 9 on the farm during the dry period (head),
X266 = graze cow 10 on the farm during the dry period (head),
X268 = graze cow 11 on the farm during the dry period (head),
X270 = graze cow 12 on the farm during the dry period (head),
X272 = graze cow 13 on the farm during the dry period (head),
X274 = graze cow 14 on the farm during the dry period (head),
X276 = graze cow 15 on the farm during the dry period (head),
X278 = graze cow 16 on the farm during the dry period (head),
X280 = graze cow 17 on the farm during the dry period (head),
X282 = graze cow 18 on the farm during the dry period (head),
X284 = graze cow 19 on the farm during the dry period (head),
X286 = graze cow 20 on the farm during the dry period (head),
X288 = graze cow 21 on the farm during the dry period (head),
X290 = graze cow 22 on the farm during the dry period (head),
X292 = graze cow 23 on the farm during the dry period (head),
X294 = graze cow 24 on the farm during the dry period (head),
X296 = graze cow 25 on the farm during the dry period (head),
X298 = graze cow 26 on the farm during the dry period (head),
X300 = graze cow 27 on the farm during the dry period (head),
X302 = graze cow 28 on the farm during the dry period (head),
X304 = graze cow 29 on the farm during the dry period (head),
X306 = graze cow 30 on the farm during the dry period (head),

X308 = graze cow 31 on the farm during the dry period (head),
X310 = graze cow 32 on the farm during the dry period (head),
X312 = graze cow 33 on the farm during the dry period (head),
X314 = graze cow 34 on the farm during the dry period (head),
X316 = graze cow 35 on the farm during the dry period (head),
X318 = graze cow 36 on the farm during the dry period (head),
X320 = graze cow 37 on the farm during the dry period (head),
X322 = graze cow 38 on the farm during the dry period (head),
X324 = graze cow 39 on the farm during the dry period (head),
X326 = graze cow 40 on the farm during the dry period (head),
X328 = graze cow 41 on the farm during the dry period (head),
X330 = graze cow 42 on the farm during the dry period (head),
X332 = graze cow 43 on the farm during the dry period (head),
X334 = graze cow 44 on the farm during the dry period (head),
X336 = graze cow 45 on the farm during the dry period (head),
X338 = graze cow 46 on the farm during the dry period (head),
X340 = graze cow 47 on the farm during the dry period (head),
X342 = graze cow 48 on the farm during the dry period (head),
X344 = graze cow 49 on the farm during the dry period (head),
X346 = graze cow 50 on the farm during the dry period (head),
X348 = graze cow 51 on the farm during the dry period (head),
X350 = graze cow 52 on the farm during the dry period (head),
X352 = graze cow 53 on the farm during the dry period (head),
X354 = graze cow 54 on the farm during the dry period (head),
X356 = graze cow 55 on the farm during the dry period (head),
X358 = graze cow 56 on the farm during the dry period (head),
X360 = graze cow 57 on the farm during the dry period (head),
X362 = graze cow 58 on the farm during the dry period (head),
X364 = graze cow 59 on the farm during the dry period (head),
X366 = graze cow 60 on the farm during the dry period (head),
X368 = graze cow 61 on the farm during the dry period (head),
X370 = graze cow 62 on the farm during the dry period (head),
X372 = graze cow 63 on the farm during the dry period (head),
X374 = graze cow 64 on the farm during the dry period (head),
X376 = graze cow 65 on the farm during the dry period (head),
X378 = graze cow 66 on the farm during the dry period (head),
X380 = graze cow 67 on the farm during the dry period (head),
X382 = graze cow 68 on the farm during the dry period (head),
X384 = graze cow 69 on the farm during the dry period (head),
X386 = graze cow 70 on the farm during the dry period (head),
X388 = graze cow 71 on the farm during the dry period (head),
X390 = graze cow 72 on the farm during the dry period (head),
X392 = graze cow 73 on the farm during the dry period (head),
X394 = graze cow 74 on the farm during the dry period (head),
X396 = graze cow 75 on the farm during the dry period (head),
X398 = graze cow 76 on the farm during the dry period (head),
X400 = graze cow 77 on the farm during the dry period (head),
X402 = graze cow 78 on the farm during the dry period (head),

GRAZING OFF ACTIVITIES (DRY COWS)

X249 = graze cow 1 off the farm during the dry period (head),

X251 = graze cow 2 off the farm during the dry period (head),
X253 = graze cow 3 off the farm during the dry period (head),
X255 = graze cow 4 off the farm during the dry period (head),
X257 = graze cow 5 off the farm during the dry period (head),
X259 = graze cow 6 off the farm during the dry period (head),
X261 = graze cow 7 off the farm during the dry period (head),
X263 = graze cow 8 off the farm during the dry period (head),
X265 = graze cow 9 off the farm during the dry period (head),
X267 = graze cow 10 off the farm during the dry period (head),
X269 = graze cow 11 off the farm during the dry period (head),
X271 = graze cow 12 off the farm during the dry period (head),
X273 = graze cow 13 off the farm during the dry period (head),
X275 = graze cow 14 off the farm during the dry period (head),
X277 = graze cow 15 off the farm during the dry period (head),
X279 = graze cow 16 off the farm during the dry period (head),
X281 = graze cow 17 off the farm during the dry period (head),
X283 = graze cow 18 off the farm during the dry period (head),
X285 = graze cow 19 off the farm during the dry period (head),
X287 = graze cow 20 off the farm during the dry period (head),
X289 = graze cow 21 off the farm during the dry period (head),
X291 = graze cow 22 off the farm during the dry period (head),
X293 = graze cow 23 off the farm during the dry period (head),
X295 = graze cow 24 off the farm during the dry period (head),
X297 = graze cow 25 off the farm during the dry period (head),
X299 = graze cow 26 off the farm during the dry period (head),
X301 = graze cow 27 off the farm during the dry period (head),
X303 = graze cow 28 off the farm during the dry period (head),
X305 = graze cow 29 off the farm during the dry period (head),
X307 = graze cow 30 off the farm during the dry period (head),
X309 = graze cow 31 off the farm during the dry period (head),
X311 = graze cow 32 off the farm during the dry period (head),
X313 = graze cow 33 off the farm during the dry period (head),
X315 = graze cow 34 off the farm during the dry period (head),
X317 = graze cow 35 off the farm during the dry period (head),
X319 = graze cow 36 off the farm during the dry period (head),
X321 = graze cow 37 off the farm during the dry period (head),
X323 = graze cow 38 off the farm during the dry period (head),
X325 = graze cow 39 off the farm during the dry period (head),
X327 = graze cow 40 off the farm during the dry period (head),
X329 = graze cow 41 off the farm during the dry period (head),
X331 = graze cow 42 off the farm during the dry period (head),
X333 = graze cow 43 off the farm during the dry period (head),
X335 = graze cow 44 off the farm during the dry period (head),
X337 = graze cow 45 off the farm during the dry period (head),
X339 = graze cow 46 off the farm during the dry period (head),
X341 = graze cow 47 off the farm during the dry period (head),
X343 = graze cow 48 off the farm during the dry period (head),
X345 = graze cow 49 off the farm during the dry period (head),
X347 = graze cow 50 off the farm during the dry period (head),
X349 = graze cow 51 off the farm during the dry period (head),
X351 = graze cow 52 off the farm during the dry period (head),
X353 = graze cow 53 off the farm during the dry period (head),

X355 = graze cow 54 off the farm during the dry period (head),
X357 = graze cow 55 off the farm during the dry period (head),
X359 = graze cow 56 off the farm during the dry period (head),
X361 = graze cow 57 off the farm during the dry period (head),
X363 = graze cow 58 off the farm during the dry period (head),
X365 = graze cow 59 off the farm during the dry period (head),
X367 = graze cow 60 off the farm during the dry period (head),
X369 = graze cow 61 off the farm during the dry period (head),
X371 = graze cow 62 off the farm during the dry period (head),
X373 = graze cow 63 off the farm during the dry period (head),
X375 = graze cow 64 off the farm during the dry period (head),
X377 = graze cow 65 off the farm during the dry period (head),
X379 = graze cow 66 off the farm during the dry period (head),
X381 = graze cow 67 off the farm during the dry period (head),
X383 = graze cow 68 off the farm during the dry period (head),
X385 = graze cow 69 off the farm during the dry period (head),
X387 = graze cow 70 off the farm during the dry period (head),
X389 = graze cow 71 off the farm during the dry period (head),
X391 = graze cow 72 off the farm during the dry period (head),
X393 = graze cow 73 off the farm during the dry period (head),
X395 = graze cow 74 off the farm during the dry period (head),
X397 = graze cow 75 off the farm during the dry period (head),
X399 = graze cow 76 off the farm during the dry period (head),
X401 = graze cow 77 off the farm during the dry period (head),
X403 = graze cow 78 off the farm during the dry period (head),

HAY BUYING ACTIVITY

X404 = buy hay (kg DM),

HAY FEEDING ACTIVITIES (TO DRY COWS)

X405 = feed hay to cow 1 during the dry period (kg DM),
X406 = feed hay to cow 2 during the dry period (kg DM),
X407 = feed hay to cow 3 during the dry period (kg DM),
X408 = feed hay to cow 4 during the dry period (kg DM),
X409 = feed hay to cow 5 during the dry period (kg DM),
X410 = feed hay to cow 6 during the dry period (kg DM),
X411 = feed hay to cow 7 during the dry period (kg DM),
X412 = feed hay to cow 8 during the dry period (kg DM),
X413 = feed hay to cow 9 during the dry period (kg DM),
X414 = feed hay to cow 10 during the dry period (kg DM),
X415 = feed hay to cow 11 during the dry period (kg DM),
X416 = feed hay to cow 12 during the dry period (kg DM),
X417 = feed hay to cow 13 during the dry period (kg DM),
X418 = feed hay to cow 14 during the dry period (kg DM),
X419 = feed hay to cow 15 during the dry period (kg DM),
X420 = feed hay to cow 16 during the dry period (kg DM),
X421 = feed hay to cow 17 during the dry period (kg DM),
X422 = feed hay to cow 18 during the dry period (kg DM),
X423 = feed hay to cow 19 during the dry period (kg DM),
X424 = feed hay to cow 20 during the dry period (kg DM),
X425 = feed hay to cow 21 during the dry period (kg DM),

X426 = feed hay to cow 22 during the dry period (kg DM),
X427 = feed hay to cow 23 during the dry period (kg DM),
X428 = feed hay to cow 24 during the dry period (kg DM),
X429 = feed hay to cow 25 during the dry period (kg DM),
X430 = feed hay to cow 26 during the dry period (kg DM),
X431 = feed hay to cow 27 during the dry period (kg DM),
X432 = feed hay to cow 28 during the dry period (kg DM),
X433 = feed hay to cow 29 during the dry period (kg DM),
X434 = feed hay to cow 30 during the dry period (kg DM),
X435 = feed hay to cow 31 during the dry period (kg DM),
X436 = feed hay to cow 32 during the dry period (kg DM),
X437 = feed hay to cow 33 during the dry period (kg DM),
X438 = feed hay to cow 34 during the dry period (kg DM),
X439 = feed hay to cow 35 during the dry period (kg DM),
X440 = feed hay to cow 36 during the dry period (kg DM),
X441 = feed hay to cow 37 during the dry period (kg DM),
X442 = feed hay to cow 38 during the dry period (kg DM),
X443 = feed hay to cow 39 during the dry period (kg DM),
X444 = feed hay to cow 40 during the dry period (kg DM),
X445 = feed hay to cow 41 during the dry period (kg DM),
X446 = feed hay to cow 42 during the dry period (kg DM),
X447 = feed hay to cow 43 during the dry period (kg DM),
X448 = feed hay to cow 44 during the dry period (kg DM),
X449 = feed hay to cow 45 during the dry period (kg DM),
X450 = feed hay to cow 46 during the dry period (kg DM),
X451 = feed hay to cow 47 during the dry period (kg DM),
X452 = feed hay to cow 48 during the dry period (kg DM),
X453 = feed hay to cow 49 during the dry period (kg DM),
X454 = feed hay to cow 50 during the dry period (kg DM),
X455 = feed hay to cow 51 during the dry period (kg DM),
X456 = feed hay to cow 52 during the dry period (kg DM),
X457 = feed hay to cow 53 during the dry period (kg DM),
X458 = feed hay to cow 54 during the dry period (kg DM),
X459 = feed hay to cow 55 during the dry period (kg DM),
X460 = feed hay to cow 56 during the dry period (kg DM),
X461 = feed hay to cow 57 during the dry period (kg DM),
X462 = feed hay to cow 58 during the dry period (kg DM),
X463 = feed hay to cow 59 during the dry period (kg DM),
X464 = feed hay to cow 60 during the dry period (kg DM),
X465 = feed hay to cow 61 during the dry period (kg DM),
X466 = feed hay to cow 62 during the dry period (kg DM),
X467 = feed hay to cow 63 during the dry period (kg DM),
X468 = feed hay to cow 64 during the dry period (kg DM),
X469 = feed hay to cow 65 during the dry period (kg DM),
X470 = feed hay to cow 66 during the dry period (kg DM),
X471 = feed hay to cow 67 during the dry period (kg DM),
X472 = feed hay to cow 68 during the dry period (kg DM),
X473 = feed hay to cow 69 during the dry period (kg DM),
X474 = feed hay to cow 70 during the dry period (kg DM),
X475 = feed hay to cow 71 during the dry period (kg DM),
X476 = feed hay to cow 72 during the dry period (kg DM),
X477 = feed hay to cow 73 during the dry period (kg DM),

X478 = feed hay to cow 74 during the dry period (kg DM),
X479 = feed hay to cow 75 during the dry period (kg DM),
X480 = feed hay to cow 76 during the dry period (kg DM),
X481 = feed hay to cow 77 during the dry period (kg DM),
X482 = feed hay to cow 78 during the dry period (kg DM).

List of Row Definitions

Rows	Definition
MILK JUL **MILK AUG** **MILK SEP** **MILK OCT** **MILK NOV** **MILK DEC** **MILK JAN** **MILK FEB** **MILK MAR** **MILK APR** **MILK MAY** **MILK JUN**	Milk production and selling reconciliation rows (kg MS) Monthly: July through to June
DMI 1 **DMI 2** **DMI 3** **DMI 4** **DMI 5** **DMI 6** **DMI 7** **DMI 8** **DMI 9** **DMI 10** **DMI 11** **DMI 12** **DMI 13** **DMI 14** **DMI 15** **DMI 16** **DMI 17** **DMI 18** **DMI 19** **DMI 20** **DMI 21** **DMI 22** **DMI 23** **DMI 24** **DMI 25** **DMI 26**	Dry matter intake limit rows (kg DM) Fortnightly: period 1 through to 26

COWME01	
COWME02	
COWME03	
COWME04	
COWME05	
COWME06	
COWME07	
COWME08	
COWME09	
COWME10	
COWME11	
COWME12	
COWME13	Metabolisable energy reconciliation rows (lactating cows)
COWME14	Fortnightly: period 1 through to 26
COWME15	(Megajoules metabolisable energy)
COWME16	
COWME17	
COWME18	
COWME19	
COWME20	
COWME21	
COWME22	
COWME23	
COWME24	
COWME25	
COWME26	
COWCP01	
COWCP02	
COWCP03	
COWCP04	
COWCP05	
COWCP06	
COWCP07	
COWCP08	
COWCP09	
COWCP10	
COWCP11	
COWCP12	
COWCP13	Crude protein reconciliation rows (lactating cows)
COWCP14	Fortnightly: period 1 through to 26
COWCP15	(kg crude protein)
COWCP16	
COWCP17	
COWCP18	
COWCP19	
COWCP20	
COWCP21	
COWCP22	
COWCP23	
COWCP24	
COWCP25	
COWCP26	
LAND	Hectares

PSN04LIM **PSN05LIM** **PSN06LIM** **PSN07LIM** **PSN08LIM** **PSN09LIM** **PSN10LIM** **PSN11LIM** **PSN12LIM** **PSN13LIM** **PSN14LIM** **PSN15LIM** **PSN16LIM** **PSN17LIM** **PSN18LIM** **PSN19LIM** **PSN20LIM** **PSN21LIM** **PSN22LIM** **PSN23LIM**	Nitrogen fertiliser application rate limits (kg N per application) Fortnightly: period 4 through to 23
MAXANN =	Annual nitrogen application rate limit (kg N)
PSDM01 **PSDM02** **PSDM03** **PSDM04** **PSDM05** **PSDM06** **PSDM07** **PSDM08** **PSDM09** **PSDM10** **PSDM11** **PSDM12** **PSDM13** **PSDM14** **PSDM15** **PSDM16** **PSDM17** **PSDM18** **PSDM19** **PSDM20** **PSDM21** **PSDM22** **PSDM23** **PSDM24** **PSDM25** **PSDM26**	Pasture dry matter reconciliation rows Fortnightly: period 1 through to 26 (kg DM)

C01MAX
C02MAX
C03MAX
C04MAX
C05MAX
C06MAX
C07MAX
C08MAX
C09MAX
C010MAX
C011MAX
C012MAX
C013MAX
C014MAX
C015MAX
C016MAX
C017MAX
C018MAX
C019MAX
C020MAX
C021MAX
C022MAX
C023MAX
C024MAX
C025MAX
C026MAX

In situ pasture transfer limits
Fortnightly: period 1 through to 26
(kg DM)

PASTSIL	=	Pasture silage reconciliation row (kg DM)
BARGRDM	=	Barley grain reconciliation row (kg DM)
WCROPSIL	=	Whole crop cereal silage reconciliation row (kg DM)

DRYMEC01
DRYMEC02
DRYMEC03
DRYMEC04
DRYMEC05
DRYMEC06
DRYMEC07
DRYMEC08
DRYMEC09
DRYMEC10
DRYMEC11
DRYMEC12
DRYMEC13
DRYMEC14
DRYMEC15
DRYMEC16
DRYMEC17
DRYMEC18
DRYMEC19
DRYMEC20
DRYMEC21
DRYMEC22
DRYMEC23
DRYMEC24
DRYMEC25
DRYMEC26
DRYMEC27
DRYMEC28
DRYMEC29
DRYMEC30
DRYMEC31

Metabolisable energy reconciliation rows
during the dry period
Cow activities: 1 though to 78
(Megajoules metabolisable energy)

DRYMEC32		
DRYMEC33		
DRYMEC34		
DRYMEC35		
DRYMEC36		
DRYMEC37		
DRYMEC38		
DRYMEC39		
DRYMEC40		
DRYMEC41		
DRYMEC42		
DRYMEC43		
DRYMEC44		
DRYMEC45		
DRYMEC46		
DRYMEC47		
DRYMEC48		
DRYMEC49		
DRYMEC50		
DRYMEC51		
DRYMEC52		
DRYMEC53		
DRYMEC54		Metabolisable energy reconciliation rows during the dry period Cow activities: 1 though to 78 (Megajoules metabolisable energy)
DRYMEC55		
DRYMEC56		
DRYMEC57		
DRYMEC58		
DRYMEC59		
DRYMEC60		
DRYMEC61		
DRYMEC62		
DRYMEC63		
DRYMEC64		
DRYMEC65		
DRYMEC66		
DRYMEC67		
DRYMEC68		
DRYMEC69		
DRYMEC70		
DRYMEC71		
DRYMEC72		
DRYMEC73		
DRYMEC74		
DRYMEC75		
DRYMEC76		
DRYMEC77		
DRYMEC78		
HAYREC	=	Hay reconciliation row (kg DM)
MAXSR)	=	Maximum stocking rate (cows/ha)